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XXIV (1938)

PART II: ZOÖLOGY

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VOLUME XXIV (1938)

PART II: ZOÖLOGY

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PART I: BOTANY AND FORESTRY

PART II: ZOÖLOGY

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Anthropology, Geology

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

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VOLUME XXIV (1938)
PART II: ZOÖLOGY

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."
— SENECA, *Naturales Quaestiones*

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A SYSTEMATIC REVISION OF THE SNAKES OF THE GENUS *CONIOPHANES* *

JOSEPH R. BAILEY

INTRODUCTION

THE genus *Coniophanes* is composed of opisthoglyph snakes belonging to the family Colubridae, subfamily Xenodontinae. The various forms range from southern Texas to northern Peru, with the greatest development of species in southern Mexico and northern Central America. *Coniophanes* has not previously received the particular attention of any investigator; the only nearly complete treatments of the genus are contained in the general or faunal works of Duméril and Bocourt (1870–1907), Cope (1876), Günther (1885–1902), and Boulenger (1896).

This revision is an outgrowth of investigations of several related xenodontine genera. It is based upon an examination of the collections of the United States museums and a few critical specimens from the collection of the British Museum of Natural History. A total of about four hundred specimens have been examined, including representatives of all the forms here recognized and nine type specimens. In all, twenty-three names have been proposed for members of this genus, of which I recognize thirteen, comprising ten species.

For courtesies facilitating the examination of specimens under their care I wish to express my appreciation to Mrs. Helen T. Gaige

* The following abbreviations are used in this paper:

AMNH = American Museum of Natural History, New York;
ANSP = Academy of Natural Sciences of Philadelphia;
BM = British Museum;
CM = Carnegie Museum, Pittsburgh;
EHT = Edward H. Taylor, University of Kansas;
FMNH = Field Museum of Natural History, Chicago;
HMS = Hobart M. Smith;
MCZ = Museum of Comparative Zoölogy, Harvard University;
MZUM = Museum of Zoology, University of Michigan;
USNM = United States National Museum.

and Dr. Norman Hartweg, of the Museum of Zoology, University of Michigan; Dr. Doris Cochran, of the United States National Museum; Dr. E. R. Dunn, of Haverford College and the Academy of Natural Sciences, Philadelphia; Messrs. Arthur Loveridge and Benjamin Shreve, of the Museum of Comparative Zoölogy, Harvard University; Dr. Edward H. Taylor, of the University of Kansas; Dr. Hobart M. Smith; Mr. Karl P. Schmidt, of the Field Museum of Natural History, Chicago; Mr. M. Graham Netting, of the Carnegie Museum, Pittsburgh; and Dr. Charles M. Bogert, of the American Museum of Natural History, New York. Mr. H. W. Parker kindly checked the specimens of *Coniophanes* in the British Museum against my key and sent me the questionable specimens. For these kindnesses I am especially grateful. I also wish to thank Mr. Parker and Mr. Roger Conant, of the Philadelphia Zoological Society, for information concerning the types of *Tachymenis decipiens* Günther in the British Museum; Dr. Otto Wettstein, of Vienna, for information and for the loan of certain specimens under his care; and the several persons at the University of Michigan who are interested in herpetology and have offered valuable aid and suggestions. Dr. E. R. Dunn, under whose direction much of this investigation was carried out, has been ever ready with helpful suggestions and criticisms, for which I am sincerely grateful.

All measurements are expressed in millimeters. Numerical characters in parentheses in descriptions represent unusual variations. Except for *fissidens fissidens* and the subspecies of *imperialis*, data on individual specimens examined have been given, and in a few instances augmented by data available to me for specimens which I have not seen. Localities not plotted on the distributional maps are marked with an asterisk in the lists of specimens examined. A few records from the literature are included on the maps if there is no reason for questioning them. The pattern drawings (Pls. I–II) were made on generalized scale diagrams, and hence do not reflect the shape of the scales. In *Coniophanes* the scales are more lanceolate than in the diagrams, so that there is a certain degree of distortion. The hemipenial drawings were made by Miss Grace Eager through the courtesy of the Museum of Zoology, University of Michigan.

Genus CONIOPHANES Hallowell

Coniophanes Hallowell in Cope, 1860 : 248. Genotype, *Coronella fissidens* Günther, by original designation.

Glaphyrophis Jan, 1863 : 54. Genotype, *G. pictus* Jan (= *C. bipunctatus*), by subsequent designation (Bailey, 1937 : 5).

Hydrocalamus Cope, 1885 : 176. Genotype, *Homolopsis quinquevittatus* Duméril and Bibron, by monotypy.

The genus *Coniophanes* was proposed in an article by Cope, introduced as follows: Genus Coniophanes Hallowell, MSS. Type *fissidens* (explained in a footnote as *Coronella fissidens* Gthr., Cat. Brit. Mus. p. 36). At the bottom of the same page is a paragraph headed *C. fissidens* Hallow. This combination had not been used in print by Hallowell up to the time of his death, which took place several months before publication of Cope's article. In a posthumous paper by Hallowell (1861 : 485), edited by Cope, the combination *Coniophanes fissidens* nob. is found. It is apparent from these facts that Cope had Hallowell's manuscript at the time he wrote the article containing the original description of *Coniophanes*. In the second article Hallowell gave a description of the genus, including only *fissidens*, which indicates a genotype by monotypy. I believe it is clear that Hallowell was responsible for the name, a description, and a type indication, which satisfies the requirements of Article 21 of the International Rules of Zoölogical Nomenclature. The International Committee on Zoölogical Nomenclature has declined to give a ruling in similar cases, but since the origin of the name and the intent of Cope's usage are perfectly clear the genus should henceforth stand as *Coniophanes* Hallowell. Cope always credited Hallowell with *Coniophanes;* most other authors have referred it to Cope.

I have previously discussed (1937 : 5) at length the status of Jan's *Glaphyrophis*.

Hydrocalamus Cope has hitherto been considered a valid monotypic genus, but I find no difference which should accord it more than specific rank within *Coniophanes*. Over forty years ago Günther (1895 : 164) wrote: "In spite of the extraordinary similarity of this snake to *Tachymenis bipunctata*, I think it advisable to retain it as a distinct genus." He and others have given only vague characters of general appearance and proportion by which it could be distinguished. I find not only that it fits all the characters of *Coniophanes* as here defined, but that it is related to *bipunctatus* and derived

from an ancestor very like *bipunctatus*. Dunn (1932), in discussing *Thamnophis lineatus*, said: "The relationship of *lineatum* to the *Thamnophis elegans* group is indisputable . . . . Believing, as I do, that the classification should reflect the relationships, I had rather see *Thamnophis* split into four genera, with *lineatum* as a member of one of them, than the present arrangement, with all four groups of *Thamnophis* as one genus, and a single lone member of one of the groups isolated as a monotypic genus." My views with regard to *quinquevittatus* might be stated in almost the same words, with a substitution of scientific names.

DESCRIPTION OF *CONIOPHANES*

Small to medium-sized xenodontine snakes; body moderate with proportionate tail; head distinct from neck. Dorsal scales smooth, without pits, in 17 to 25 rows *reducing one to four times by the loss of the paravertebral rows* (rarely the last reduction, third or fourth, takes place by loss of the third lateral rows). Anal and subcaudals divided. Head scales normal in number and arrangement; nasal divided or semidivided; 1 or 2 pre- and 2 postoculars; temporals 1–2; upper labials 7 or 8 (rarely 9). Pupil of eye round. Maxillary teeth 8 to 15, subequal, followed by a gap and 1 or 2 moderately enlarged grooved fangs; mandibular and palatine teeth subequal.

The generalized color pattern consists of a dark middorsal stripe and a dark lateral stripe on either side on a grayish brown ground. Various modifications occur. A light stripe through the upper labials is present, and there is usually at least a faint trace of a light temporal stripe through the top of the eye.

Hemipenis variable as follows:[1]

A. Capitate, with well-developed proximal spines
  B. Cap not bifurcate at tip, most basal of hooks enlarged
    C. About 40 hooks and spines ..... *bipunctatus* and *quinquevittatus*
    C. About 30 or fewer hooks and spines
      D. About 15 to 19 hooks and spines
        E. Hemipenis short ..... *f. fissidens*
        E. Hemipenis long ..... *lateritius*
      D. About 30 hooks and spines ..... *brevifrons*
  B. Cap slightly bifurcate at tip
    F. Four enlarged basal hooks and about 26 smaller spines *dromiciformis*
    F. No enlarged basal hooks, about 30 spines .. *piceivittis* and *schmidti*

[1] The hemipenis of *fissidens andresensis* is not known, but in all probability it is similar to that of *fissidens fissidens*. The only specimen of *lateritius* examined was a juvenile, and so may not be entirely typical of the adult condition.

A. No hooks or spines, deeply bifurcate, the forks being calyculate but not capitate, a small smooth area at the tip of each fork; in everted condition inflated lateral sacs present below the place of forking
imperialis subsp. and *meridanus*

STATUS OF QUESTIONABLE FORMS

Erythrolamprus mentalis Werner and *E. grammophrys* Dugés have both been considered forms belonging to *Coniophanes*. They are known only from the type specimens, which have not been critically reëxamined; hence my conclusions concerning them are tentative. In the description of *mentalis* Werner did not state his reasons for placing it in *Erythrolamprus* (sensu Boulenger), so that it has been assumed that the posterior fangs are grooved. In several other places Werner has erred in generic assignments through failure to examine dentition properly. For instance, his supposedly aglyphous *Dromicus w-nigrum* has been shown by Cochran (1928) to be identical with the opisthoglyphous *Ialtris dorsalis;* his supposedly opisthoglyphous *Erythrolamprus labialis*, described in the same paper as *mentalis*, is synonymous with *Rhadinaea lateristriga* (*Urotheca lateristriga* auctorum), a fact unmistakably disclosed by the drawing of the head; his *Erythrolamprus longicaudus* has been synonymized under *Rhadinaea* (*Liophis*) *decorata* by Amaral (1929 : 46). Furthermore, the only dorsal count given for *mentalis* is 17, the usual number in *Rhadinaea*, but in *Coniophanes* found only in *meridanus*. Since dorsal reduction was not indicated I have preferred to allocate *mentalis* to *Rhadinaea* until its status can be definitely settled. The type, which is in the Naturhistorische Museum in Hamburg, should be reëxamined with the critical characters in mind.

Concerning *E. grammophrys* the situation is much the same. In the original French description Dugés said he thought the posterior teeth were grooved, but in a later Spanish description (1890 : 402) he admitted that they were *rotos* ("broken"). Again the dorsals are 17, with no indication of reduction. Taylor (1933 : 98) records the presence of the type in the collection of the Alfredo Dugés Museo of Guanajuato, Mexico, but he was unable to examine the specimen except through the bottle. The coloration and scutellation as described would again indicate a *Rhadinaea* affinity (*Rhadinaea laureata?*), as would the type locality.

Tachymenis decipiens Günther has been appropriately and, I believe, correctly renamed *Rhadinaea güntheri* by Dunn (1938 : 198).

In spite of certain contradictory characteristics its relationships appear to be with *Rhadinaea persimilis* Dunn rather than with any species of *Coniophanes.*

EVOLUTION AND SUPERSPECIFIC GROUPS

Natural superspecific alliances among the species of *Coniophanes* are evident, and are helpful in tracing evolutionary trends. Two species, *lateritius* and *dromiciformis,* occupy rather isolated positions on the basis of color pattern, but too little material of these forms has been available to enable one to determine accurate structural affinities. The other species are allied in four groups of two species each, which are characterized by scutellation, male sexual characters, and color pattern. The forms in each group appear to occupy separate but adjoining ranges, for in no locality has more than a single member of a group been found. Table I summarizes the principal similarities and differences between the groups.

Morphological and geographical evidence indicates that the groups mentioned have followed divergent evolutionary lines. Generalizations for the genus as a whole do not seem to hold; rather, each group has differentiated along separate lines, with different characters undergoing modification. Thus one group has increased in size and scutellation, whereas another has increased even more in scutellation but not, apparently, in size. Still another indicates a possible reduction in size and dorsal scutellation. With the exception of the *fissidens* group and *clavatus* of the *imperialis* group all the forms have developed distinctive and diverse color patterns, which are usually modifications of the generalized scheme. Probably all but the members of the *fissidens* group have undergone penial modifications.

The end form in each group exhibits characters which are found in it alone, but other characters common to several forms seem to focus upon the *fissidens* group. It is therefore regarded as the most generalized group, and for this reason and its availability it is made the basis for comparison.

FISSIDENS GROUP

Although the *fissidens* group is considered the most generalized — and probably its members are most like the primitive forms of the genus — none of them is held to be ancestral to the genus. In fact,

TABLE I

Summary of Characteristics of Supraspecific Groups in *Coniophanes*

Form (Group names in italics)	Dorsals	Ventrals	Caudals	Anal ridges, mature ♂♂	Temporal stripe	Hemipenis	Distinctive group color
fissidens fissidens	19–21	111–136	62–89	Present	Absent	Single, spinous, capitate	Generalized
fissidens andresensis	19	144	?				
brevifrons	19	138	105				
bipunctatus	21	130–145	85–94	Present	Absent	Single, spinous, capitate	Large regular ventral spots
quinquevittatus	21	157–163	63–70				
lateritius	19	150	91	?	Absent	Single, spinous, capitate	Black head, red body
schmidti	23–25	158–174	87–115	Present	Present	Bilobed, spinous, capitate	Broad black dorsal band
piceivittis	25	158–173	79–91				
dromiciformis	19	120–132	66–82	Absent?	Absent	Bilobed, spinous, capitate	Black stripes on frontal
imperialis imperialis	19	127–140	68–78	Absent	Present	Bifurcate, spineless, calyculate	Generalized or modified
imperialis clavatus	19(21)	117–141	71–94				
imperialis copei	19	127–141	65–80				
meridanus	17	122–134	83–87				

the evidence indicates that speciation within the group is actively going on at present. This group, composed of *fissidens fissidens* (from central Colombia into southern Mexico), *fissidens andresensis* (San Andrés Island, about 125 miles east of Nicaragua), and the closely related *brevifrons* (Ecuador) are nearly coextensive in range with the entire genus, with *f. fissidens* the central form.

The fact that both *andresensis* and *brevifrons* are known from single specimens has made it necessary to assume that the characters of the types represent average conditions in these forms (subject to normal variation).

Important geographic variation in the large percentage of specimens of *f. fissidens* from eastern Mexico are the 19 scale rows (instead of 21), 7 upper labials (instead of 8), and high ventral and low caudal counts, although the population differences are not sufficient to warrant taxonomic recognition. It is significant that both *andresensis* and *brevifrons* have 19 scale rows and higher ventral counts than does *f. fissidens*. Nineteen scale rows or 7 upper labials are of very rare occurrence in *f. fissidens* south of Mexico. Thus to the north, south, and on an isolated island to the east of 21-row *fissidens* are 19-row high ventral count populations. These peripheral populations are thought to be relicts of an ancestral population, which extinction reduced in the center of the range to a greater or a lesser extent. Since that extinction *f. fissidens* has repopulated much of this area and has simultaneously undergone evolutionary change in an increase of dorsal rows to 21 and a decrease in ventral number (most marked on the present southern periphery).

The more conventional interpretation of parallel peripheral differentiation from a central stock finds some support. Of the two Colombian specimens available one has 7 upper labials on one side and the dorsal formula 17–21–16, and thus shows the same tendencies toward scale reduction as the east Mexican population. The other specimen has the minimum subcaudal number, 62 (first incomplete), which is also similar to the east Mexican *fissidens*.

Contradicting this arrangement are the minimum ventral numbers (111 and 113) in these same specimens. In the low ventral and caudal averages for southern specimens the direction of variation is opposed to the high numbers in *brevifrons*, so that it is necessary to derive *brevifrons* from a stock other than the most proximal *fissidens* population.

In dorsal and labial reduction, then, and in subcaudal count the most southern specimens show evidence of approach toward the most northern specimens; the ventral number varies in the opposite direction. The evidence of southern dorsal and labial reduction is slight, particularly since the only specimen concerned is a very young individual, which may be abnormal. Or, this reduction may be real and correlated with the reduction of abdominal scutellation and hence indicative of evolutionary dwarfing. The subcaudal number is a much more variable and plastic character in the group than the ventral number, so that the ventrals remain the most reliable character.

It should be explained that the theories of subsequent central and peripheral differentiation are not inharmonious. If my first theory be accepted, the differential characters of the present peripheral populations may be the result of primary peripheral differentiation (differentiation on the original periphery). Partial extinction resulting in the disappearance of the central population (or its restriction to a small area) would provide the essentials for subsequent repopulation accompanied by secondary peripheral differentiation (differentiation peripheral, but within the original limits of the range). This would account for the marked geographic variation from Colombia to Guatemala and would permit secondary differentiation to take place from the east Mexican population, spreading southward, or from a Central American center, spreading both southward and northward and becoming intermixed with the Mexican population. That the suggested extinction has almost certainly occurred, at least in the southern part of the range, is evidenced by the discontinuity in range and characters between *fissidens* and *brevifrons*, and even by the apparent absence of *fissidens* in eastern Panama. This latter hiatus in the range may reflect only the inadequacy of collections from the mountainous and Caribbean coastal regions.

The hypothetical ancestor of the *fissidens* group having 19 scale rows and a higher ventral number is the most logical generic prototype. If a 21-row ancestor is assumed it would be necessary to derive 19 rows no fewer than four times, whereas under the present arrangement 21 rows require a single derivation. In addition, multiple reduction is contrary to the evidence of generic ancestry and the trends in other groups.

BIPUNCTATUS GROUP

The *bipunctatus* group differs markedly from the *fissidens* group in its larger size, higher ventral count, and the possession of large dark ventral spots regularly arranged (Pl. I, Fig. 5). The ventral spotting of *fissidens* is highly variable, from almost no spotting to a profusion of spots, with no great geographic correlation. In occasional specimens of *f. fissidens* these spots are regularly arranged as in the *bipunctatus* group (Pl. I, Fig. 4), but they are seldom as regular and never as large as in the latter group. The dorsals are consistently 21 in the *bipunctatus* group and 19–21 in the *fissidens* group. In ventral count the *bipunctatus* group compares with *f. fissidens* as follows (approximate averages):

fissidens (125) ⟶ *bipunctatus* (140) ⟶ *quinquevittatus* (160)

This is the size sequence according to available material, with *quinquevittatus* the largest. The hemipenial structures of *bipunctatus* and *quinquevittatus* are similar and differ from that of *fissidens* chiefly in the more numerous spines.

In general coloration *bipunctatus* is rather similar to *fissidens*, but is less strongly marked (except ventral spots), which produces a much faded appearance. The lateral stripes on specimens of *bipunctatus*, when discernible, are on the fourth and fifth and two adjacent half-scale rows, but the lower border especially is seldom well defined. In *fissidens* (21 scale rows) the lower rows, either four and a half or five and a half, and the tips of the ventrals are dark. A broad ill-defined dorsal stripe is occasionally apparent in *bipunctatus*. In *quinquevittatus* the stripes are well defined and in their distribution resemble *bipunctatus* in the exclusion (at midbody) of the lateral stripe from the two lowermost dorsal rows. In pattern as in most other characters *bipunctatus* links *quinquevittatus* with the *fissidens* group.

LATERITIUS GROUP

Of the little-known *lateritius* I have been able to examine only a single specimen, which agrees closely with the published descriptions of two other specimens. The known distribution of *lateritius* is unusual for a member of this genus, for its presence on the Mexican plateau singles it out as being the only typically upland form. Structurally it does not differ greatly from the postulated prototype of

the *fissidens* group. The short upper labial series (7) is found in two thirds of the specimens of *fissidens* from eastern Mexico and in the distantly related *meridanus*, but is an anomaly elsewhere in the genus. In coloration and pattern it is quite unique. The absence of body stripes, the bold mottling of the chin, and the tiny white spots on the head are suggestive of relationship with *bipunctatus*, but on the basis of present material either proposal of relationship would be open to serious question.

piceivittis group

The *piceivittis* group, composed of *piceivittis* and *schmidti*, has differentiated further morphologically from the ancestral stock than have any of the forms previously discussed. The dorsal scale rows of *schmidti* are 23–25 and of *piceivittis* 25; hence the arrangement:

ancestral form ⟶ *schmidti* ⟶ *piceivittis*

This arrangement is most logical from the standpoint of coloration, for the lateral stripe of *schmidti* more closely resembles the generalized condition. The subcaudal count of *schmidti* is the highest in the genus, which suggests a specialization belying the direct ancestry to *piceivittis* indicated above.

These two species have the highest number of dorsals and ventrals in the genus, but a proportionate size correlation is not appreciable in my material; the largest specimens of *fissidens* exceed the largest of the *piceivittis* group, although it should be kept in mind that the discrepancy is not great and that the series of *fissidens* is far nearer completion.

The broad dorsal black band of the *piceivittis* group is thoroughly characteristic. The very distinctive light temporal stripes in these forms are also found in the *imperialis* group. This would indicate an early common origin of these two groups from the central stock and, if *imperialis* has not undergone subsequent reduction in size, then the *piceivittis* group has increased in size in keeping with the increase in scutellation.

The hemipenis most closely resembles that of *dromiciformis*. The maxillary tooth series is somewhat shorter than in the other groups. In these two characters there is slight difference between *schmidti* and *piceivittis*.

DROMICIFORMIS GROUP

The sole member of this group resembles the *fissidens* group in the gross features of pattern, but the body pattern is complicated by fine white lines through the dark stripes, and the head pattern is peculiar to *dromiciformis*. The peculiarities of color and pattern are considered specializations, whereas scutellation and the lack of anal ridges show relationships with the *imperialis* group. It is probably of more recent common descent from the *imperialis* stock than is the *piceivittis* group. The seemingly anomalous distribution of *dromiciformis*, Ecuador and Peru, serves as an additional illustration of how present distributional patterns have been effected by extinction.

IMPERIALIS GROUP

The gross morphology and the superficial resemblance of certain members of the *imperialis* group to *f. fissidens* are very great indeed, but they are features which tend to obscure the true relationships. On the basis of size or scutellation *fissidens* and *imperialis* cannot be certainly separated in parts of the overlapping ranges, and only the presence of light temporal stripes in *imperialis* and minor color differences serve to distinguish *imperialis clavatus* from *f. fissidens* superficially. The very dissimilar hemipenes and the lack of anal ridges in mature males of the *imperialis* group offer distinguishing criteria which possibly make this group deserving of generic rank.

It seems probable that *meridanus* of the Yucatan Peninsula is a reduced derivative of the *imperialis* stock, which has lost dorsal rows and body pattern. It is the only member of the genus with 17 scale rows. The body is unicolor except for the striking nape pattern. It is barely possible that the *imperialis* and the *fissidens* groups diverged at a time when the progenitors had 17 scale rows, and that *meridanus* has retained the primitive number and *imperialis* undergone an increase parallel to that in other groups.

The remaining members of the *imperialis* group are the three races of *imperialis*. They agree in having 19 scale rows and a slightly higher ventral and caudal count than does *f. fissidens*, which they otherwise resemble closely. The northern peripheral populations of *imperialis*, i.e. *imperialis, copei*, and the Campeche–Quintana Roo population of *clavatus* differ from *imperialis clavatus* (forma typica) in having a slightly different and more contrasting color pattern.

On the other hand, the supposedly degenerate *meridanus* has lost the generalized striped pattern, which seems to me perfectly in keeping with the theory of reduction.

It is only in these same peripheral populations of *imperialis* that the ventral and ventral minus caudal numbers reach their highest limits and averages. In Campeche the trends are too slight to admit taxonomic recognition at present, but *imperialis imperialis* and *imperialis copei* are well defined. The striping in these two is much more sharply marked (Pl. I, Figs. 1, 3), and the ventrals average higher and the caudals lower, so that in the ventral minus caudal figure there is very little overlapping with *clavatus*. These two forms inhabit definitely arid regions, in contrast to the range of the species elsewhere. From this we might postulate parallel modification in style of pattern and scutellation under similar environmental conditions.

Hartweg and Oliver (1939) point out that the Tehuantepecan region may be a center of relict snake populations. If this is true, a common genetic connection between *imperialis* and *copei* may be reasonable, instead of independent origins from *clavatus*, as the parallel-modification theory would suggest. The fact that the interrelationships of these forms are sufficiently close to permit intergradation between *imperialis* and *clavatus* and between *copei* and *clavatus* makes it unnecessary to hypothesize further.

KEY TO THE FORMS OF *CONIOPHANES*

A. Dorsals in 23–25 rows
  B. Lateral dark stripes broad (4–5 scales wide), sharply defined on lower edge . . . *piceivittis*. Tehuantepec to Costa Rica, p. 29 (Pl. II, Fig. 2)
  B. Lateral dark stripe narrow ($\frac{1}{2}$–$1\frac{1}{2}$ scales wide), shading gradually to ventrals . . . . . *schmidti*. Yucatan Peninsula, p. 31 (Pl. II, Fig. 1)
A. Dorsals in 21 or fewer rows
  C. Belly with a double row of large regular dark spots, one pair to a ventral; dorsals in 21 rows; chin mottled
    D. Ventrals fewer than 150; no conspicuous lateral dark stripe *bipunctatus*. Southern Mexico to Honduras, p. 24 (Pl. I, Fig. 5)
    D. Ventrals more than 150; a conspicuous lateral dark stripe *quinquevittatus*. Southern Vera Cruz to Petén, p. 26 (Pl. I, Fig. 6)
  C. Belly immaculate or with numerous small black spots; chin usually spotted, but not mottled (unless head is black)
    E. Head and neck black for about ten scales, followed by a cream collar; body unicolor, red in life *lateritius*. Mexican Plateau, Guadalajara to Guerrero, p. 28

E. Head and neck not black
F. Dorsals in 19 rows; 3 to 5 black lines on top of head between eyes ..... *dromiciformis.* Ecuador and Peru, p. 32
F. Dorsals in 17–21 rows; no black lines between eyes
G. Dorsals in 19–21 rows; no light temporal stripe through top of eye; anal ridges in mature males; hemipenis unifurcate, spinous, capitate
H. Dorsals in 19 rows; caudals 105; frontal shorter than its distance from the tip of the snout *brevifrons.* Ecuador, p. 23
H. Dorsals in 19–21 rows; caudals fewer than 90; frontal equal to its distance from the tip of the snout
I. Dorsals usually in 21 rows, except in Mexico; ventrals fewer than 137 *fissidens fissidens.* Southern Mexico to central Colombia, p. 14 (Pl. I, Fig. 4)
I. Dorsals in 19 rows; ventrals 144 *fissidens andresensis.* San Andrés Island, p. 23
G. Dorsals in 17 to 19 rows (very rarely 21); a light temporal stripe through top of eye; hemipenis bifurcate, spineless
J. Body nearly unicolor, reddish brown; dorsals in 17 rows... *meridanus.* Tip of Yucatan Peninsula, p. 43
J. Body with a lateral and, usually, a middorsal stripe; dorsals in 19 rows
K. Middorsal stripe one and two half scales wide *imperialis imperialis.* Northern Vera Cruz to southern Texas, p. 34 (Pl. I, Fig. 1)
K. Middorsal stripe if present not more than one scale wide
L. Middorsal stripe very narrow and continuous; lateral dark stripe distinctly darker on upper half; ventrals minus caudals, males 50–60, females 58–71..... *imperialis copei.* West coast of Oaxaca, Mexico, p. 42 (Pl. I, Fig. 3)
L. Middorsal stripe variable, broken into spots, missing, or continuous but about one scale wide; lateral dark stripe usually uniformly dark (except anteriorly); ventrals minus caudals lower than in *imperialis copei* except in Campeche and Quintana Roo *imperialis clavatus.* Southern Vera Cruz to Honduras, p. 35 (Pl. I, Fig. 2)

Coniophanes fissidens fissidens (Günther)

(Pl. I, Fig. 4; Pl. III, Fig. 1; distributional map, Fig. 2)

Coronella fissidens Günther, 1858 : 36.

Coniophanes fissidens Cope, 1860 : 248; Hallowell, 1861 : 485; Cope, 1865 : 195; 1871 : 216; 1876 : 138; 1879 : 270; Sumichrast, 1880 : 181; Duméril and Bocourt, 1886 : 650–651, pl. 41, fig. 3; Cope 1900 : 1242, pl. 26, fig. 8.

Coniophanes proterops Cope, 1860 : 249 (type locality, Orizaba); 1876 : 138 (part); Duméril and Bocourt, 1886 : 654.
Coniophanes punctigularis Cope, 1860 : 248 (type locality, Honduras); 1876 : 137; Duméril and Bocourt, 1886 : 652; Barbour and Amaral, 1924 : 130; Amaral, 1929 : 217.
Dromicus chitalonensis Müller, 1878 : 407 (type locality, Hacienda de Chitalon bei Mazatenango, Guatemala).
Tachymenis fissidens Garman, 1883 : 60; Günther, 1895 : 161.
Erythrolamprus violaceus Cope, 1887 : 77 (*nomen nudum*).
Erythrolamprus fissidens Cope, 1887 : 77; Dugés, 1893–94 : 376; Boulenger, 1896 : 207; Werner, 1896 : 11; Boettger, 1898 : 110; Werner, 1904 : 349; 1925 : 144.
Erythrolamprus punctigularis Cope, 1887 : 77.
Erythrolamprus imperialis Boulenger, 1896 : 206 (part, specimen d).
Erythrolamprus bipunctatus Boettger, 1898 : 110.

Cotypes. — Six in the British Museum, numbers 56.3.17.35–6, 57.7.31.48, 57.7.31.54, 60.6.17.17, and an unnumbered specimen.

Type locality. — Mexico.

Range. — Central Vera Cruz and Michoacán south to Medellín, Colombia, avoiding high mountains and the Yucatan Peninsula.

Diagnosis. — A *Coniophanes* with 19–21 scale rows; mature males with anal ridges; ventrals fewer than 137, caudals fewer than 90. Light temporal stripe absent; never with two regular rows of large ventral spots.

Description. — Dorsals 21–17 to 19–13 (lower formulae common in Mexico), mature males with anal ridges; ventrals 111 to 136; caudals 62–89. Upper labials 8, fourth and fifth in eye (7, third and fourth in eye frequently in Mexico); lower labials 9 or 10, 5 or 6 in contact with chin shields. Oculars 1–2 or 2–2; temporals 1–2.

Maxillary teeth 12–15 followed by a gap and 1 or 2 enlarged grooved fangs. Hemipenis single throughout, 3 or 4 enlarged basal hooks or spines and 11 to 14 smaller more distal ones, tip capitate.

Ground color dull brown or gray with black punctulations. A light line extends through the upper labials. A poorly developed stripe on the median row may be present. The rows lateral to this become successively lighter until the middle of the fifth or the sixth row (fourth if 19 rows), upon which row there is another dark line, which may or may not be well developed. The sides below the fifth or the sixth (fourth) row may be dark and unicolor, or they may be only slightly darker than the ground color; in either case pigment extends onto the tips of the ventrals. Chin and labials rather densely punctulated with brown pigment. Venter usually with small dark

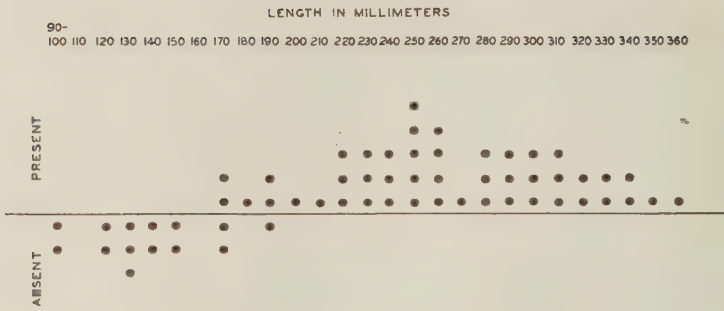

Fig. 1. Relationship between body length and anal ridges in male *Coniophanes fissidens fissidens*

spots scattered throughout, which are more or less arranged in two rows, or are occasionally restricted to the anterior part of the body.

The type of Cope's *proterops* has the 19 dorsal rows and the 7 upper labials which characterize a considerable proportion of Vera Cruz specimens. It is a female, but the lack of a light temporal stripe definitely assigns it to *fissidens*. Cope considered *proterops* a southern relative of *imperialis imperialis*, as have other authors who have recognized the name. Hence both 19-row *fissidens* and *imperialis clavatus* have been included under *proterops*, which adds greatly to the confusion in the literature.

The type of *punctigularis* is a male with all the essential features of *fissidens*. The middorsal band is 5 scales wide anteriorly and 3 wide posteriorly. Anteriorly it is represented by a double row of darker spots, which are evident posteriorly only as scalloped outer borders of the band. This type of coloration is frequent in western Guatemala and Mexico. In the original description Cope stated that *punctigularis* differed from *fissidens* in having fewer ventrals, characterizing *fissidens* with 140. This number is higher than that of any *fissidens fissidens* I have seen, and the 125 ventrals (121 according to Cope) in the type of *punctigularis* are just about the average for Honduras males.

In the first appearance of the name *violaceus* it was ascribed to Hallowell, but in this reference Cope was in error. No description or designation accompanied the name.

Blanchard (1931) has analyzed in detail the character of the anal

TABLE II

VARIATION IN DORSAL AND UPPER LABIAL FORMULAE IN *CONIOPHANES F. FISSIDENS*

Dorsal formula	Number of specimens		
	Colombia to Mexico	West Mexico	East Mexico
21----19----17	100	25	5
20-21----19----17	3	..	..
21----19----17-16	1	..	..
19----21----19----17	4	1	1
21----19----17----15	1	2	..
19----21----19----17----15	..	..	1
17----19----21----19----17-16	1	..	..
19----17	..	..	2
19----17-16	..	1	..
19----17----15	2	1	5
17----19----17----15	..	1	..
19----17----15----13	..	..	1

Summary *	Dorsals			Upper labials			
Scale rows	Colombia to Mexico	West Mexico	East Mexico	No.	Colombia to Mexico	West Mexico	East Mexico
21	124	40	7	8	125.5	37.5	5
19	2	3	8	7	.5	5.5	10
%19	1.7	7.5	53.3	%7	.3	14.7	66.7

* I have included in the summary seventeen additional specimens which I have seen but for which I do not have complete dorsal formulae.

ridges.[2] Tabulation of this character for male *f. fissidens* (Fig. 1) confirms Blanchard's conclusion that these structures have a definite relationship to male size which is probably correlated with sexual maturity. I have also observed them occasionally in large females, but in females they do not reach the state of development that is attained in males of equal size.

Many of the questions involving geographic variation in *f. fissidens* (Tables II–V) can be elucidated by future collections. The material

[2] I have previously referred to these structures as "anal keels" (1937: 6). I here use Blanchard's term for the reason he gives (Blanchard, 1931). For some genera the term "tubercle" seems more appropriate, but if the ridges and the tubercles are homologous it would be best to establish one term and to describe the differences.

Fig. 2. Distribution of *Coniophanes fissidens*

most needed in the *fissidens* group is *f. fissidens* from Colombia and the east coast from Guatemala to northern Vera Cruz and additional specimens of *f. andresensis* and *brevifrons*. It is entirely possible that Colombian specimens may deserve future taxonomic recognition on the basis of a low total of abdominal scutes; the peculiarities of the Vera Cruz (Mexican) population almost demand it now. I have refrained from recognizing it at this time for several reasons. The peculiar characters of this population may be summarized as follows:

(1) 7 upper labials, 66.7 per cent constant;
(2) 19 scale rows, 53.3 per cent constant;
(3) highest ventral minus caudal number, 55.5 per cent distinctive.

In the first two of these characters (Table II) the west Mexican population is intermediate between the east Mexican and the Central American ones. The usefulness of a character index (3, above) in illustrating geographic variation may be seen by comparing Table V with Tables III and IV. By this character index (Table V) the differentiation between the east Mexican population and the others north of Honduras is complete (100 per cent). Nearly all the Guatemala British Honduras material, however, is from the west coast of Guatemala, whereas most of that from Honduras–Nicaragua is from the north coast (Caribbean drainage basin) of Honduras (see Fig. 2).

TABLE III

FREQUENCY DISTRIBUTION OF VENTRAL SCALE NUMBERS IN *CONIOPHANES F. FISSIDENS*

Counts for specimens h, i, and l to u (Boulenger, 1896 : 208) are included in addition to the material I have examined.

Population	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	Mean
Males																											
Colombia–Panama	1	0	1	2	0	1	0	1	0	0	1	1	0	0	0	1	..	..	..	..	..	..	..	..	..	..	9–117.2
Costa Rica	..	..	..	1	0	0	1	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5–117.2
Nicaragua–Honduras	..	..	..	..	..	..	..	..	1	0	2	0	2	1	2	0	1	0	0	1	..	..	..	..	..	..	10–123.9
Guatemala–British Honduras	..	..	..	..	1	0	4	6	6	3	5	4	3	2	..	..	..	..	..	..	..	..	..	..	..	..	34–119.9
West Mexico	..	..	..	..	2	0	0	0	1	2	3	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	11–120.9
East Mexico	..	..	..	..	..	..	..	1	1	0	0	0	0	0	0	2	1	0	2	2	0	1	..	..	..	..	10–126.6
Totals	1	0	1	3	3	1	5	10	10	5	11	6	6	4	2	3	2	0	2	3	0	1	..	..	..	..	79–121.0*
Females																											
Panama	..	..	..	..	..	..	1	0	0	0	0	1	0	1	0	1	1	..	..	..	..	..	..	..	..	..	5–123.2
Costa Rica	..	..	..	..	..	..	..	..	..	..	1	1	1	0	1	2	1	..	..	..	..	..	..	..	..	..	7–124.3
Nicaragua–Honduras	..	..	..	..	..	..	..	..	..	..	..	..	..	4	0	1	1	3	4	2	2	1	..	..	..	..	18–127.9
Guatemala–British Honduras	..	..	..	..	..	..	..	..	1	2	3	4	2	5	4	3	1	4	2	..	..	..	..	..	..	..	31–124.2
West Mexico	..	..	..	..	..	..	..	..	..	..	2	3	1	0	3	2	1	3	0	1	0	1	..	..	..	..	17–125.2
East Mexico	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	0	1	0	0	2	1	7- 132.4
Totals							1	0	1	2	6	9	4	10	8	9	5	10	7	5	2	3	0	0	2	1	85–126.2*

* Mean of the means.

TABLE IV

FREQUENCY DISTRIBUTION OF SUBCAUDAL SCALE NUMBERS IN *CONIOPHANES F. FISSIDENS*

Counts for specimens h, i, and l to u (Boulenger, 1896 : 208) are included in addition to the material I have examined.

Population	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	Mean
Males																													
Colombia–Panama	1	0	1	1	0	0	0	0	1	1	0	0	1	1															7–68.7
Costa Rica									1	0	0	0	0	0	0	0	0	1	1										3- 76.3
Honduras													1	0	0	0	0	1	0	1	1	0	1						5- 80.0
Guatemala–British Honduras															2	0	2	6	6	4	6	0	1						27- 80.0
West Mexico																					1	0	0	1	0	0	1	2	5–86.6
East Mexico				1	0	0	1	0	0	1	0	1	1	0	1														6–71.2
Totals	1	0	1	2	0	0	1	0	2	2	0	1	3	1	3	0	2	8	7	5	8	0	2	1	0	0	1	2	53–77.3*
Females																													
Colombia Panama		1	1	0	0	0	0	0	0	0	0	0	1	0	1														4–69.3
Costa Rica		1	0	0	0	0	1	0	0	0	1	0	0	1															4- 69.5
Nicaragua–Honduras				1	0	1	0	0	1	1	0	2	0	3	1	0	0	1											11- 72.6
Guatemala–British Honduras							1	0	1	3	3	3	0	1	1	1	2	0	0	1									17–73.6
West Mexico									1	0	0	0	1	0	2	2	1	0	0	0	0	0	1						8–76.5
East Mexico						2	0	1																					3–67.7
Totals		2	1	1	0	3	2	1	3	4	4	5	2	5	5	3	3	1	0	1	0	0	1						47–71.5*

* Mean of the means.

TABLE V

FREQUENCY DISTRIBUTION OF VENTRAL MINUS SUBCAUDAL SCALE NUMBERS IN *CONIOPHANES F. FISSIDENS*

Counts for specimens h, i, and l to u (Boulenger, 1896 : 208) are included in addition to the material I have examined.

Population	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	Mean
Males																																						
Colombia–Panama												1	0	0	0	0	0	1	1	1	3																	7–49.9
Costa Rica								2	0	0	0	0	1																									3–40.7
Honduras							1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1													5–43.6
Guatemala–B. H.*		1	0	2	0	2	4	2	4	5	1	2	2	1	0	0	1																					27–40.0
West Mexico	1	2	0	0	2																																	5–34.0
East Mexico																					1	0	1	1	0	0	0	1	0	1	0	0	1					6–57.5
Totals	1	3	0	2	2	2	5	5	4	6	1	3	4	1	0	0	1	1	1	1	4	0	1	1	1	0	0	1	0	1	0	0	1					53–44.3†
Females																																						
Panama																			1	0	0	1	0	0	0	0	0	1	1									4–55.5
Costa Rica																		1	0	0	0	0	0	0	0	0	0	1	1	0	0	1						4–58.7
Nicaragua–Honduras																	1	0	0	1	2	0	1	0	1	2	0	0	1	2								11–55.5
Guatemala–B. H.*												2	1	0	2	0	1	2	2	2	0	1	3	1													17–50.4
West Mexico												1	0	1	2	1	1	1	0	0	0	1																8–48.0
East Mexico																														1	0	0	0	1	0	0	1	3–64.7
Totals												3	1	1	4	2	3	4	3	4	1	3	3	2	2	0	2	3	3	0	1	0	1	0	0	1	47–55.3†

* British Honduras. † Mean of the means.

In the third character the east Mexican and the Honduras populations overlap. Adequate material from these areas would show whether the degree of overlap is small enough to admit further splitting. Additional specimens from Guatemala to Vera Cruz on the east coast are necessary before we can accurately determine the interrelationships of these populations. When the material is sufficient to enable one to trace and compare geographic variation independently on the east and the west coasts interesting results of much significance may result. Unfortunately most of the east Mexican specimens now in museums are in poor condition, and nearly half have incomplete tails.

A nomenclatorial question would also be involved in recognition of another Mexican form. The six cotypes of *fissidens*, which are from "Mexico," have 21 dorsals and 8 upper labials (cf. *proterops*, p. 16). Five of them agree with the east Mexican population in abdominal scutellation. The name would be dependent upon the characters utilized in distinguishing the two forms; if the low dorsal and labial formulae be used *proterops* is applicable; if abdominal scutellation be employed the use of *fissidens* would be proper, and *punctigularis* would be applicable to the southern population.

Material examined:

Colombia: Medellín (2, AMNH, 35724, 35493).

Panama: (1, USNM, 13569); Boquete (5, MZUM, 57959, 57961–64); Progreso (2, MZUM, 57960, 57965); Madden Dam (1, MCZ, 38230); Barro Colorado Island (1, MZUM, 63702; 1, MCZ, 18817); Sabanas, East of Panama City (2, MCZ, 39759–60, 2 heads); Two Falls, Chagres River, 400 feet (2 heads).

Costa Rica: (6, USNM, 68857, 32617–21); Siquirres (2, National Museum, Costa Rica); Coen Dispensary (1, MCZ, 19331); El General (1, AMNH, 17307); Surrubres (1, MCZ, 15327); Suretka (1, MCZ, 19341); Palmilla* (1, ANSP, no no.).

Nicaragua: Matagalpa (1, MCZ, 9557; 1, MZUM, 56500).

Honduras: (1, ANSP, 3742, type of *punctigularis*); Yoro, Subirana Valley (1, MCZ, 38760; 2, FMNH, 21890, 21819); Yoro, Portillo Grande* (3, MCZ, 38761–63; 1, FMNH, 21891); Tela (5, MCZ, 38758, 19337, 20214, 19007, 31663; 2, MZUM, 63353, 58415); Lancetilla (1, MZUM, 74431; 1, MCZ, 38758); Mataderos Mountains* (1, MCZ, 38764); San Pedro Sula (2, FMNH, 5304–05); Guaymas District* (2, MCZ, 21774–75; 3, MZUM, 74432); Ulúa District, Garcia Plantation* (2, MZUM, 74429–30); Las Limas* (1, MCZ, 38757); Progreso (1, MCZ, 26862); Progreso District, Ulúa River* (1, MCZ, 21807); La Libertad (1, MCZ, 38764).

Guatemala: (1, FMNH, 22911; 1, USNM, 56325); Alta Verz Paz* (1, USNM, 37842); Finca Cipres (10, MCZ, 22120–29); Finca Carolina (3, MCZ, 22130–32); Olas de Moco, near Moco, Solola (34, FMNH, 20163–67, 20454–81); El Porvenir, San Marcos, 3,400 feet (9, FMNH, 20335, 20344–50, 20365).

British Honduras: Stann Creek District, Cockscomb Mountains, 1,150 feet (1, CM, 8485); El Cayo District, Cohune Ridge (1, MZUM, 80710).

Mexico: Chiapas: Tonalá (1, AMNH, 4305; 1, EHT, 5329); Chicharras (1, USNM, 46663); Finca Esperanza, 6 kilometers northeast of Esquintla, 150–450 meters (16, MZUM, no nos.). Oaxaca: (1, USNM, 30525); Tehuantepec (1, BM, 71.2.7.35; 3, USNM, 30167–69); Cafetal Mirador* (1, AMNH, 19748); Tapanatepec (5, MZUM, no nos.; 12, MCZ, 27702–13). Michoacán: Carrizal (1 BM, 1914.1.28.141). Tabasco: Teapa (1, USNM, 46590). Vera Cruz: Texola (1, ANSP, 15333); Mirador, 80 kilometers west of Vera Cruz (7, USNM, (3) 6369, 46452–53, 12112, 25034); San Andreas Tuxtla (1, USNM, 46389); Orizaba (1, USNM, 12117); Potrero* (1, MZUM, 80939); Jalapa? (1, BM, 81.10.31.67); Jalapa (1, USNM, 5285, type of *proterops;* 1, MCZ, 16029).

Coniophanes fissidens andresensis Bailey

(Distributional map, Fig. 2)

Coniophanes fissidens andresensis Bailey, 1937 : 4.

Holotype. — MCZ, 31867, adult female, San Andrés Island, about 125 miles east of Nicaragua.

Diagnosis. — A *Coniophanes* with dorsal formula 19–17–15, 8 upper labials, and 144 ventrals.

The only known specimen of this form falls within the range of variation of *fissidens fissidens* except in ventral number. In this character as well as dorsal formula it bears closest resemblance to the *Vera Cruz* population of *fissidens. East* Mexican specimens with 19 scale rows, however, invariably have been found to have 7 upper labials. The ventral range in Vera Cruz females, 129–136, is sufficiently low to indicate that this character probably provides nearly complete differentiation between the two populations.

This isolated island form could scarcely have originated directly from the Mexican population, nor it is likely that it is a recent arrival from the adjacent mainland. According to my theory of evolution in the *fissidens* group, *andresensis* was derived from a wide-ranging form resembling Vera Cruz *fissidens* and *andresensis.* Schuchert (1935 : 363) believes San Andrés may have been connected with the mainland during Pliocene times, but *andresensis* may be a relic of fortuitous dispersal.

Coniophanes brevifrons Bailey

Coniophanes brevifrons Bailey, 1937 : 3–4.

Holotype. — ANSP, 3349, adult male, Ecuador, collected by James Orton.

Diagnosis. — A *Coniophanes* with 19 scale rows; mature males with anal ridges; frontal shorter than its distance from the tip of the snout; no black stripes between eyes; caudals 105.

Description of holotype. — Body slender, head distinct from neck, tail long. Top of snout flat, the internasals on nearly the same plane as frontal and parietals in longitudinal section. Dorsals 19–17–16 (last reduction on one side only), anal ridges present; ventrals 138, caudals 105. Upper labials 8, fourth and fifth in eye; lower labials 10, 6 in contact with chin shields. Oculars and temporals 1–2. Frontal projected just reaches posterior tip of rostral.

Maxillary teeth 12 followed by a gap and 2 enlarged grooved fangs. Hemipenis short, stout, single throughout, with 3 enlarged basal hooks and 24 smaller and more distal spines; tip distinctly capitate, sulcus forking at base of cap. Body 357 mm., tail 200 mm.

Since only the type of *brevifrons* is available, we must await further material before we can say anything about its distribution or variation. I believe its affinities, like those of *andresensis*, are with a onetime wide-ranging form of the *fissidens* group. It is very distinct from the Colombian *fissidens* and even more distinct from *dromiciformis*. It is less well differentiated from *andresensis* and Mexican *fissidens*, the other peripheral forms in the same group.

Coniophanes bipunctatus (Günther)

(Pl. I, Fig. 5; distributional map, Fig. 3)

Coronella bipunctata Günther, 1858 : 36.
Glaphyrophis pictus Jan, 1863 : 304 (no type locality); Jan and Sordelli, 1866, XVIII, pl. 5, fig. 4.
Coniophanes bipunctatus Cope, 1866 : 128; Duméril and Bocourt, 1886 : 653, pl. 40, fig. 8; Amaral, 1929 : 216.
Erythrolamprus bipunctata Cope, 1887 : 77; Boulenger, 1896 : 208; Werner, 1925 : 144.
Tachymenis bipunctata Günther, 1895 : 161.

Holotype. — A young male in the British Museum, locality unknown.

Range. — Southern Mexico to Honduras.

Diagnosis. — A *Coniophanes* with a regular double row of large dark ventral spots; dorsal pattern usually poorly developed; ventrals fewer than 150, subcaudals more than 80.

Description.[3] — Dorsals 21–17, mature males with anal ridges;

[3] Ventral and caudal figures include those given by Boulenger (1896 :209).

ventrals, males 130–140 (8 average 135.0), females 134–145 (13 average 138.6); subcaudals, males 91–94, females 84–88. Upper labials 8, fourth and fifth in eye (9, fifth and sixth); lower labials 10 or 11, 6 or 7 in contact with chin shields; oculars 1(2)–2(1); temporals 1–1 or 1–2.

Maxillary teeth about 15 followed by a gap and 2 enlarged grooved fangs. Hemipenis (FMNH, 4237) single throughout, 4 large basal hooks followed by 41 smaller spines and a capitate tip.

The dorsal color pattern on the body is usually indistinct, and the snake almost uniformly brown. The specimen selected for the pattern

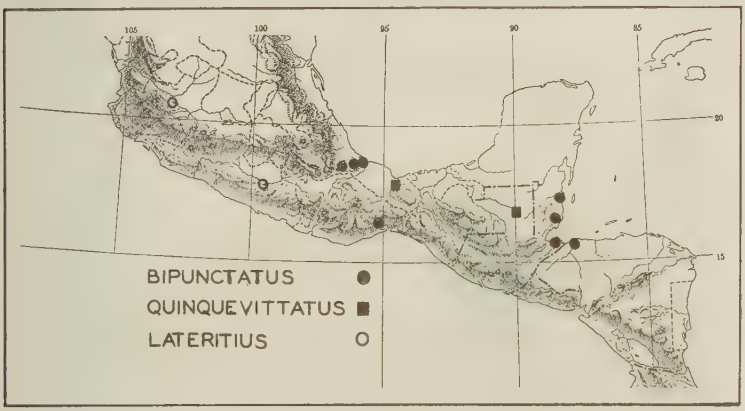

Fig. 3. Distribution of *Coniophanes bipunctatus*, *C. quinquevittatus*, and *C. lateritius*

drawing has the stripes better developed than any other I have seen, and so serves best to illustrate the distribution of the markings. The principal variations are in the intensity of the dark stripes and the distinctness of their borders. The middorsal dark band may be lighter or narrower than in the drawing; the lower border of the lateral dark band usually shades gradually into the ground color of the sides. The black spots at the extreme tips of the ventrals may be indistinct. The large ventral spots become ocelli in large specimens, and a few irregular ventral spots may occur. The common border of the first and second scale rows may be darker than the ground color. The head is dark brown above, frequently bearing some light flecks of yellow. The labials and chin are mottled with

large dark spots. There is a fine light line through the posterior labials from the lower corner of the eye to the angle of the mouth. On the whole, the distribution of markings is like that in *quinquevittatus*, which, however, presents a much more contrasting pattern, and in which the spots at the extreme tips of the ventrals are usually lacking.

The material at hand does not permit a discussion of geographic variation, but it may be pointed out that the ventrals average highest in British Honduras and lowest in Mexico. The sexual dimorphism in ventral and subcaudal numbers is slight but definite.

The specimen recorded by Boettger (1898 : 110) from Nicaragua is *fissidens fissidens*, according to Dr. Dunn, who has examined it.

Dr. E. H. Taylor and Mr. K. P. Schmidt have both informed me that they have taken this species in semiaquatic situations.

Data for material examined:

Museum no.	*Sex*	*Ventrals*	*Caudals*	*Body length*	*Tail length*	*Locality*
MCZ, 22046–47	?	Heads	..	...	...	Tulóa, Honduras
FMNH, 20578	♂	134	93	402	211	Puerto Barrios, Guatemala
4235	♂	137	..	362	...	British Honduras
4237	♂	136	..	340	...	Do.
USNM, 30343	♂	130	92	165	82	Tehuantepec, Mexico
30226	♂	131	94	165	82	Orizaba, Vera Cruz, Mexico
6756	♀	137	..	350	...	Guatemala
FMNH, 20207	♀	137	84	189	89	Puerto Barrios, Guatemala
20491	♀	135	..	532	....	Do.
4236	♀	137	..	560	...	British Honduras
USNM, 26061	♀	142	88	438	210	Belize, British Honduras
24902	♀	141	..	363	...	Do.
55860	♀	145	..	401	...	Do.
AMNH, 22736	♀	134	..	290	...	Mexico
EHT, 4586	♀	138	85	406	190	Tierra Colorado, Vera Cruz, Mexico (near Cordoba)
4585	♀	138	..	409	...	Do.

Coniophanes quinquevittatus (Duméril and Bibron)

(Pl. I, Fig. 6; distributional map, Fig. 3)

Homalopsis quinquevittatus Duméril and Bibron, 1854 : 975–76

Calopisma quinquevittatum Jan, 1863 : 55, 244; Jan and Sordelli, 1868 : II, pl. 2, fig. 1 — var. *mexicana* Jan, l.c.; Jan and Sordelli, l.c., fig. 2.

Hydrops lubricus Cope, 1871 : 217 (type locality, Coatzacoalcos River, Vera Cruz).

Hydrocalamus quinquevittatus Cope, 1885 : 176; 1887 : 75; Günther, 1895 : 164. Duméril and Bocourt, 1895 : pl. 55, fig. 6, and pl. 60, fig. 3; Cope, 1900 : 698, 1092, 1241, pl. 25, fig. 7; Werner, 1913 : 26; 1925 : 144; Amaral, 1929 : 218.

Holotype. — Probably in the Paris Museum, locality unknown.

Range. — Southern Vera Cruz, Mexico and Petén, Guatemala.

Diagnosis. — A *Coniophanes* with a regular double row of large dark ventral spots; dorsal pattern well developed; ventrals more than 150, subcaudals fewer than 80.

Description. — Dorsals 21–17, mature males with anal ridges; ventrals 157–163, subcaudals 63–70. Upper labials 8, fourth and fifth in eye; lower labials 10 or 11, 6 in contact with chin shields; oculars 1–2; temporals 1–2.

Maxillary teeth 10–12 followed by a gap and 2 enlarged grooved fangs. Cope (1900 : pl. 25, fig. 7) figures the hemipenis, which is essentially like that of *bipunctatus*.

The color pattern is similar to that of *bipunctatus*, but the longitudinal stripes are more distinct. The two lowest dorsal rows are white, with scattered gray shadings. The venter, except for the prominent dark spots, is nearly immaculate. A dark lateral stripe covers the fourth, fifth, and adjacent two half rows (third, fourth, and two halves posteriorly). The median line of the scales in this stripe is lighter. A similar stripe occupies the median and adjacent two half rows, from which the dorsum becomes increasingly lighter as the dark lateral stripes are approached. The lateral dark stripe extends through the eye to the tip of the snout. The chin scales, lower labials, and 6 anterior upper labials are light, each with a prominent black spot. There are traces of a light line both anterior and posterior to the top of the eye. The top of the head is dark gray. The illustration of *mexicana* (Jan and Sordelli, 1866 : pl. 2, fig. 2) shows a row of dark spots along the first lateral scale row.

The differences which have led to the recognition of *Hydrocalamus* lie in the shape of the head. It is less distinct from the neck, the snout is shorter, and the eye is smaller than in *bipunctatus*. Although these differences are readily apparent, I do not think they justify generic removal of this species from its near relatives. Furthermore, these differences are no more marked than are those of the characters of head shape in any two of these three species: *brevifrons, dromiciformis,* and *fissidens*.

In erecting the genus *Hydrocalamus* Cope considered it an aquatic

snake on the basis of general appearance and the fact that his specimen (type of *Hydrops lubricus*) was caught on the bank of the Coatzacoalcos River. No conclusive evidence concerning its habitat preferences has come to light. Dr. Carl Hubbs secured a specimen at Lake Petén from native boys, who called it *culebra de agua*, and since its more generalized relative, *bipunctatus*, is known to have aquatic tendencies it would not be surprising to find that *quinquevittatus* is a truly aquatic species. The resemblance between the color pattern of *quinquevittatus* and those of certain aquatic snakes, especially *Helicops carinicaudus* and *Liodytes alleni*, is quite striking. It is extremely doubtful that these similarities are due to genetic relationships, but they may represent parallel adaptations to an aquatic life.

The range of *quinquevittatus* is surrounded on three sides by that of *bipunctatus*, but as yet the two have not been taken at the same locality. Future collecting may indicate exclusive or overlapping ranges, but in the latter event it is probable that an ecological segregation would be found.

The two specimens I have seen are the only ones with definite records of localities.

Data for material examined:

Museum no.	*Sex*	*Ventrals*	*Caudals*	*Body length*	*Tail length*	*Locality*
MZUM, 79060	♀	161	..	561	...	Flores, Petén, Guatemala
USNM, 61182	♂	157	70	460	151	Coatzacoalcos River, Vera Cruz (type of *Hydrops lubricus*)

Coniophanes lateritius Cope

(Distributional map, Fig. 3)

Coniophanes lateritius Cope, 1861 : 524; 1900 : 1029; Amaral, 1929 : 217.
Tachymenis melanocephala Peters, 1870 : 876 (no type locality).
Tachymenis lateritia Garman, 1883 : 61; Günther, 1895 : 162.
Erythrolamprus lateritius Cope, 1887 : 78; Boulenger, 1896 : 205; Werner, 1925 : 144.
Erythrolamprus melanocephalus Cope, 1887 : 78.

Holotype. — Apparently lost; not to be found in the collections of the United States National Museum or the Academy of Natural Sciences of Philadelphia.

Type locality. — Guadalajara, Mexico.

Range. — West central portion of the Mexican plateau.

Diagnosis. — A *Coniophanes* with 19 scale rows; head and neck black for about 10 scales; body unicolor, bright red in life.

Description (EHT, 5198, juvenile male). — Head distinct from neck, body slender, tail moderate. Dorsals 19–17, reducing by loss of the paravertebral rows opposite ventrals 100 (right side) and 103 (left). Ventrals 150, subcaudals 91. Upper labials 7, third and fourth in eye; lower labials 9, 4 and 5 in contact with anterior and posterior chin shields respectively; oculars and temporals 1–2.

Head and neck dense black for 9 scales, with a few tiny scattered white spots on the top of the head. The next four scales form a collar, which was creamy white in life;[4] the posterior border of the collar slightly darker than the rest of the body, which was bright red in life, lighter below. In alcohol the color is reddish brown. A white line extends through the upper labials from the first labial to the anterior ventral corner of the sixth, where the ends are continuous, with a white bar across the throat just anterior to the first ventral. The lower labials and throat bear large dark spots. Ventrally the black on the neck includes only the outer edges of the ventrals.

Maxillary teeth about 10, followed by a gap and an enlarged grooved fang. The specimen is too young to offer an accurate picture of the hemipenis, but the following facts could be made out: hemipenis 12 caudals long; longitudinal ridges extend to the eighth caudal; spinous eighth to tenth; capitate tenth to twelfth. The character and position of the sulcus could not be determined. Body length 126 mm., tail 52 mm.

Material examined. — EHT, 5198, 12 miles south of Puente de Tixtla, Guerrero, Mexico, collected July 16, 1936, by E. H. Taylor.

Coniophanes piceivittis Cope

(Pl. II, Fig. 2; distributional map, Fig. 4)

Coniophanes piceivittis Cope, 1869 (July) : 149; Sumichrast, 1880 : 181; Duméril and Bocourt, 1886 : 656, pl. 41, fig. 2.
?*Tachymenis taeniata* Peters, 1869 (Dec.) : 876 (no type locality).
Tachymenis piceivittis Günther, 1872 : 20; 1895 : 160; Werner, 1925 : 144.
Coniophanes piceivitis Amaral, 1929 : 217.

Cotypes. — Two, USNM, 30265, Chihuitan, Oaxaca, Mexico.

Range. — Tehuantepec to Bebedero, Costa Rica, on the west coast, and central Honduras.

[4] Record of color in life taken from notes of E. H. Taylor.

Diagnosis. — A *Coniophanes* with 25 scale rows; a small subpreocular; a broad median stripe and broad lateral (4–5 scales wide) dark stripes with sharply defined edges; subcaudals, males 82–91, females 78–84.

Description. — Dorsals 25–21 to 23–25–17, anal ridges in mature males; ventrals, males 158–168, females 160–173; subcaudals, males 82–91, females 78–84. Upper labials 8, fourth and fifth in eye; lower

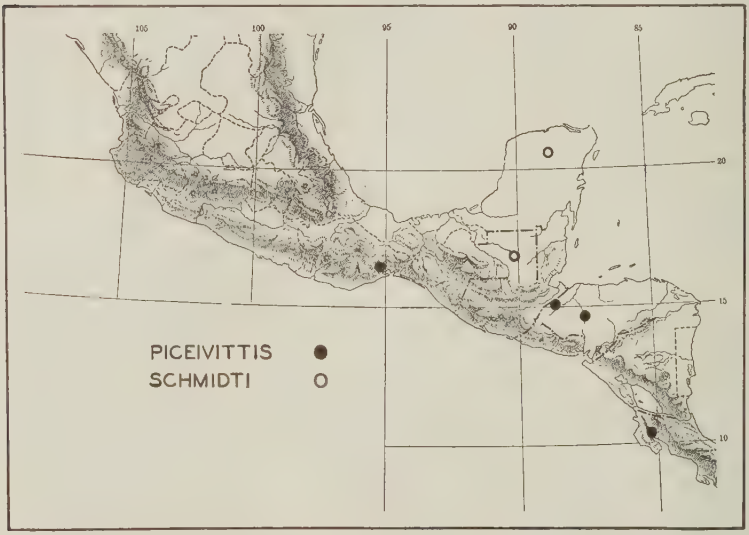

Fig. 4. Distribution of *Coniophanes piceivittis* and *C. schmidti*

labials 10, 6 in contact with chin shields. Oculars 2–2, including a small subpreocular; temporals 1–2.

Head with a light stripe through top of eye, continuous with the dorsolateral light lines or interrupted on the neck. Labials and chin spotted with dark brown or black. Body with a black dorsal stripe 5 to 7 scales wide. A black lateral stripe on either side 3 and 2 half scales to 5 and 2 half scales wide separated from the dorsal stripe by a narrow dorsolateral light stripe 1 and 2 half scales wide. The lower edge of the lateral dark stripe is sharply defined, contrasting with the light lower rows. Lowest two rows faintly flecked with dark. Belly nearly immaculate.

Hemipenis (MCZ, 38756) 10 caudals long, spines starting opposite sixth caudal, very slightly enlarged basally, 32 in all; capitate, faintly bilobed at tip. Maxillary series short, 8 to 11 followed by a gap and 1 or 2 enlarged grooved fangs.

Data for material examined:

Museum no.	*Sex*	*Dorsals*	*Ventrals*	*Caudals*	*Body length*	*Tail length*	*Locality*
MZUM, 82723	♂	25–25–21	164	87	230	87	Vicinity of Tehuantepec, Oaxaca, Mexico
82726	♂	25–25–21	168	91	218	86	Do.
82725	♂	25–25–21	162	76 +	210	67 +	Do.
82724	♂	25–25–19	162	82	204	70	Do.
82727	♂	25–25–19	167	85	157	56	Do.
USNM, 30265	♂	25	159	88	390	154	Chihuitán, Oaxaca (cotype)
MZUM, 82904	♂	23–25–17	162	91	162	59	Copán, Honduras
MCZ, 21184	♂	23–25–19	164	72 +	broken	..	Garcia Plantation, Ulúa River, Honduras
Vienna *	?	25	158	90	?	?	Bebedero, C. R.
BM, 1926.4.26.1†	♀	25	173	84	?	?	Mexico
MZUM, 82722	♀	25–25–19	170	78	180	56	Vicinity of Tehuantepec
65620	♀	23–25–19	172	81	407	136	Copán, Honduras
MCZ, 38756	♀	25–25–19	160	80	221	79	La Libertad, Honduras
USNM, 30265	♀	23–25–19	171	79	361	120	Chihuitán, Oaxaca (cotype)

* Data from notes of E. R. Dunn.
† Data from notes of Roger Conant.

Coniophanes schmidti Bailey

(Pl. II, Fig. 1; Pl. III, Fig. 2; distributional map, Fig. 4)

Erythrolamprus piceivittis Boulenger, 1896 : 209.
Coniophanes piceivittis Stuart, 1935 : 53; Gaige, 1936 : 302; Schmidt and Andrews, 1936 : 179.
Coniophanes schmidti Bailey, 1937 : 1–3.

Holotype. — MZUM, 73043, adult male, Chichen Itza, Yucatan.

Range. — Central Petén, Guatemala, to the tip of the Yucatan Peninsula.

Diagnosis. — A *Coniophanes* with 23–25 dorsal rows; a small subpreocular; a broad median and narrow lateral ($\frac{1}{2}$ to $1\frac{1}{2}$ scales wide) dark stripes; sides shaded with brown, darkest bordering the lateral stripe; subcaudals, males 101–115, females 87–103.

Description. — Dorsals 25–25–19 to 21–23–19, anal ridges in mature males; ventrals, males 158–174, females 162–174; subcaudals,

males (91?) 101 115, females 87–103. Upper labials 8, fourth and fifth in eye; lower labials 9 or 10, 5 or 6 in contact with chin shields. Oculars (1) 2–2, including a small subpreocular; temporals 1–2.

Color and pattern like those of *piceivittis* except on the sides. The lateral black stripes are $\frac{1}{2}$ to $1\frac{1}{2}$ scales wide, below which the brown shaded sides become gradually lighter to the tips of the ventrals. The contrast between the lateral black stripe and the bordering lower rows is not sharp. Dentition and hemipenis about as in *piceivittis*.

This species has been recorded as *piceivittis* a number of times in the literature. All the records for Petén and Yucatan, as well as that of specimen b (Boulenger, 1896 : 209) from "Mexico," refer to *schmidti*.

Data for material examined (MZUM, 73043, holotype; others, except BM specimens, paratypes):

Museum no.	*Sex*	*Dorsals*	*Ventrals*	*Caudals*	*Body length*	*Tail length*	*Locality*
MZUM, 73043	♂	23–25–19	170	101	372	175	Chichen Itza
73039	♂	25–25–19	169	110	390	181	Do.
73041	♂	25–25–19	167	108	155	66	Do.
68706	♂	21–23–19	167	102	340	156	Do.
FMNH, 20633	♂	23–25–19	174	115	304	146	Do.
MZUM, 74894 *	♂	25–25–19	158	...	150	...	La Libertad, Petén
BM (Boul. a) †	♂	25	162	91	?	?	Yucatan
BM (Boul. b)	♀	25	164	93	?	?	Mexico
MZUM, 74893	♀	23–23–19	165	87	411	149	La Libertad
73040	♀	23–25–19	170	95	246	99	Chichen Itza
73042	♀	25–25–19	174	103	163	62	Do.
MCZ, 22065	♀	23–25–19	171	100	310	145	Do.

* Ventrals recorded as 146 by Stuart (1935 : 53).
† Sex questionable.

Coniophanes dromiciformis (Peters)

Tachymenis dromiciformis Peters, 1863 : 273.
Coniophanes dromiciformis Cope, 1866 : 128; 1868 : 104; Amaral, 1929 : 216.
Coniophanes signatus Garman, 1892 : 91 (type locality, Guayaquil).
Erythrolamprus dromiciformis Cope, 1891 : 676; Boulenger, 1896 : 205; Werner, 1909 : 236; 1925 : 144.

Cotypes. — Probably in the Zoologischen Museums, Berlin; from Guayaquil, Ecuador.

Range. — Ecuador and Peru, Guayaquil the only definite locality.

Diagnosis. — A *Coniophanes* with 19 scale rows; frontal longer

than its distance from the tip of the snout; a black line which trifurcates on the frontal; usually fine white lines through the dark median and lateral stripes.

Description. — Dorsals (17) 19–17, anal ridges apparently absent in mature males; ventrals, males 120 130, females 123–132; subcaudals, males 77–82, females 66–80. Upper labials 8 (9), fourth and fifth in eye; lower labials 9 or 10, 5 or 6 in contact with chin shields. Oculars 1 (2)–2; temporals 1–2. Frontal distinctly longer than its distance from the tip of the snout.

On the body there are a dark median dorsal stripe 3 and 2 half scales to 5 scales wide and dark lateral bands, including the tips of the ventrals and extending to the middle of the fourth lateral row. The borders of these stripes are not sharply differentiated, but there are usually fine white streaks along the mid-lines of rows 1 to 3 and the paravertebral rows. These streaks may become obsolescent in old specimens. The dark of the median row extends to the posterior end of the frontal, where it trifurcates, the two outer branches following the sutures of the frontal onto the prefrontals, and the median branch following the center of the frontal to the prefrontals. The dark of the paravertebral rows diverges just behind the head and extends along the supraoculars to the prefrontals. Thus there are five black stripes on the head between the eyes, but in old specimens the two outer stripes may have disappeared. In a juvenile specimen they are confluent with a semicircular dark line originating at the angle of the jaw, curving dorsally, and then extending forward. Traces of this feature may be seen in some older specimens in which the paravertebral and supraocular stripes have become continuous. There is a dark line from the center of the eye to the nostril, and another broader one extends from the center of the eye backward, forming the upper border of the lateral band. Labials and chin are spotted with dark, venter with fine brown punctulations or small scattered spots or both.

Maxillary series 12–14 followed by a gap and 2 enlarged grooved fangs. Hemipenis (MCZ, 12426) 7 caudals long, bilobed for the length of the seventh caudal; 4 basal spines, of which one is distinctly enlarged, 26 others of varying sizes, but largest basally; sulcus forking opposite the sixth caudal at the base of the capitate tip.

All the material that I have seen is old, and none of it is in the best condition. I cannot be certain that a well-preserved series

would not show anal ridges, at least in old males. Although there are a number of literature records for this species, Guayaquil is the only definite locality given; the others are recorded from Ecuador and Peru.

Data for material examined:

Museum no.	*Sex*	*Dorsals*	*Ventrals*	*Caudals*	*Body length*	*Tail length*	*Locality*
FMNH, 16941	♂	19–17	130	..	245	...	Guayaquil
MCZ, 12426	♂	17–19–17	124	80	250	131	Peru
ANSP, 3355	♂	19–17	122	77	126	62	Guayaquil
3350	♀	19–17	130	74	240	116	Do.
3352	♀	?	126	75	poor condition		Do.
3347	♀	19–17	126	..	285	...	Ecuador
3736	♀	19–17	131	71	poor condition		Peru

Coniophanes imperialis imperialis (Baird and Girard)

(Pl. I, Fig. 1; distributional map, Fig. 5)

Taeniophis imperialis Girard, 1855 : 215 (*nomen nudum*, locality, Matamoras); Baird and Girard in Baird, 1859 : 23, pl. 19, fig. 1.
Coniophanes imperialis Cope, 1861 : 74; 1875 : 38; 1876 : 138; Stejneger, 1891 : 505; Stejneger and Barbour, 1917 : 104; 1923 : 117; Amaral, 1929 : 217 (part); Stejneger and Barbour, 1933 : 126–127; Brown, 1937 : 234.
Glaphyrophis lateralis Jan, 1863 : 304 (part, type locality restricted to Tampico [Bailey, 1937 : 6]).
Rhadinaea imperialis Cope, 1880 : 44; 1885 : 381.
Tachymenis imperialis Garman, 1883 : 61.
Erythrolamprus imperialis Cope, 1887 : 77; 1891 : 676; Boulenger, 1896 : 206 (part); Brown, 1901 : 92; 1903 : 554; Werner, 1925 : 144.
Tachymenis fissidens Günther, 1895 : 161–162 (part).
Coniophanes imperialis imperialis Cope, 1900 : 1090.

Holotype. — USNM, 2060, adult male, Brownsville, Texas. Locality given on specimen is Matamoras.

Range. — Cameron County, Texas, to northern Vera Cruz, where intergradation with *clavatus* occurs.

Diagnosis. — A *Coniophanes* with 19 scale rows; bifurcate, spineless hemipenis; light temporal stripe; a middorsal dark band 1 and 2 half scales to 3 scales wide; ventral minus caudal number, males over 49, females over 60.

Description. — Dorsals 19–17 or 19–15; ventrals, males 127–137, females 135–140; subcaudals, males 71–77, females 68–78; ventral minus subcaudal number, males 55–60, females 62–71. Upper labials 8, fourth and fifth in eye; lower labials 9, 5 in contact with chin

shields. Maxillary teeth 10–12 followed by a gap and 1 or 2 enlarged grooved fangs. Hemipenis long and slender; a few very minute spines present; bifurcate with calyculate forks.

Lateral dark bands cover the $3\frac{1}{2}$ lowest lateral rows and the tips of the ventrals. A median dark band with sharply demarcated borders occupies the median 1 and 2 half scale or median 3 scale rows. The dark bands are dark gray or brown. Between the median and the lateral stripes the color is light grayish tan, beginning abruptly as light dorsolateral stripes 2 to 3 scales behind the parietals. Venter nearly immaculate, chin with few small brown spots. A light line beginning on the rostral extends through the top of the eye and backward in the temporal region for a distance of about two thirds the length of the parietals. Upper labials with a light stripe running through them, spotted below and dark-margined above.

For discussion of variation and intergradation see under *clavatus* (p. 37).

Material examined. — Texas: Cameron Co. (2, USNM, 17067–68); Brownsville (4, MZUM, 75816; MCZ, 13825-26; CM, 864). Tamaulipas: Matamoras (1, USNM, 2060, type); Hacienda La Clemintina near Forlón, 68 miles south of Ciudad Victoria (3, EHT, 4582–84); Manuel (1, MCZ, 17473). Vera Cruz (intergrades with *clavatus*): Toxtlacuaya (1, EHT, 4563), Jicaltepec (1, ANSP, 11708); Tuxpan (1, USNM, 25204), Jalapa (2, BM, 81.10.31.63–4).

Coniophanes imperialis clavatus (Peters)

(Pl. I, Fig. 2, distributional map, Fig. 5)

Coronella fissidens Günther, 1858 : 36 (part).
Glaphyrophis lateralis Jan, 1863 : 304 (part); Jan and Sordelli, 1866 : pl. 5, fig. 3.
Dromicus clavatus Peters, 1864 : 388; Duméril and Bocourt, 1890 : 711–713, pl. 45, fig. 2; Günther, 1894 : 113; Boulenger, 1894 : 177.
Coniophanes proterops Cope, 1876 : 138 (part).
Rhadinaea proterops Cope, 1885 : 381.
Erythrolamprus proterops Cope, 1887 : 77 (part).
Erythrolamprus imperialis Dugés, 1893–94 : 376; Boulenger, 1896 : 206 (part); Werner, 1896 : 11; Ruthven, 1912 : 326–327; Werner, 1925 : 144 (part).
Tachymenis fissidens Günther, 1895 : 161–62 (part).
Coniophanes imperialis proterops Cope, 1900 : 1097–8 (part); Dunn and Emlen, 1932 : 31.
Coniophanes imperialis Amaral, 1929 : 217 (part); Stuart, 1935 : 53; Gaige, 1936 : 302.
Liophis clavatus Amaral, 1929 : 171.
Coniophanes imperialis clavatus Bailey, 1937 : 5–6; Andrews, 1937 : 359.

Holotype. — Probably in the Zoologische Museum, Berlin; from Mexico.

Range. — Vera Cruz to northern Honduras, on the east coast.

Diagnosis. — A *Coniophanes* with 19 scale rows; spineless, bifurcate hemipenis; light temporal stripe present; middorsal stripe missing, broken into spots or continuous and about 1 scale wide;

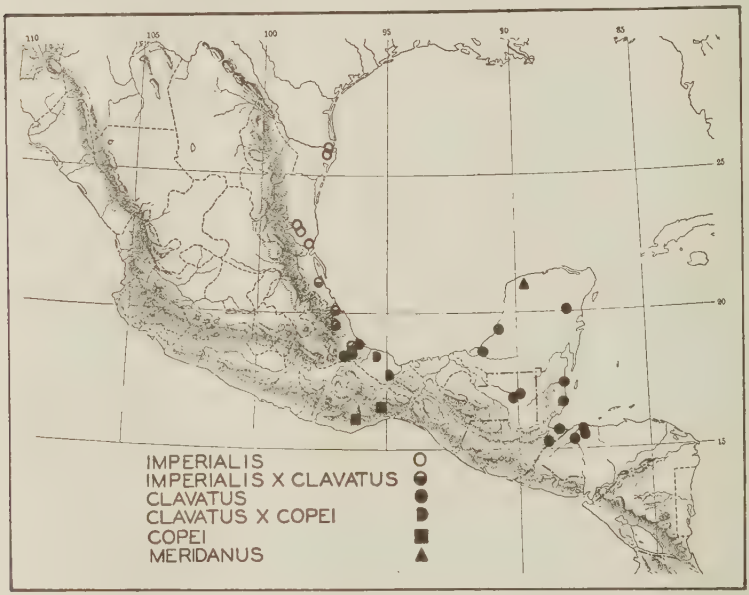

FIG. 5. Distribution of the *Coniophanes imperialis* group

ventral minus caudal number, males usually fewer than 50, females usually fewer than 61.

Description. — Dorsals 19–17 or 19–15 (a single specimen has 21–19–17); ventrals, males 117–132, females 121–141; subcaudals, males 75–94, females 71–85; ventrals minus subcaudals, males 27–49, females 36 64. Upper labials 8, fourth and fifth in eye; lower labials 9 or 10, 5 or 6 in contact with chin shields; oculars 1(2)–2. Dentition and hemipenis as in *imperialis imperialis.*

Pattern rather variable. A dark median stripe is usually present and occupies most of the middorsal row. At the overlap of the scales

it is usually somewhat widened and intensified, which produces a spotted appearance. Occasionally this stripe is lacking entirely, or it may be narrow and continuous, as in *copei* (Vera Cruz intergrades). The bordering dorsal scales are gray or brown, punctulated with black. A lateral dark band extends from the middle of the fourth (fifth) row onto the tips of the ventrals. This is typically almost uniformly dark gray except anteriorly, where it is bicolored. The light temporal stripe and the dark upper margins of the upper labials are present, as in all the rest of the *imperialis* group. The labials, and to a lesser degree the chin, are densely spotted with black. The belly is usually conspicuously spotted with black in the anterior portion, but the black may extend to the vent or be lacking except on the chin.

Since present material of *imperialis* and *copei* is too restricted to show noticeable geographic variation, they are discussed here in conjunction with the more wide-ranging and variable *clavatus*. These three forms meet and intergrade in the state of Vera Cruz. In the northern part of the state the specimens have the broad dorsal stripe of *imperialis*, but in scutellation are closer to *clavatus*. A specimen from Jicaltepec seems closer to *imperialis*, but has the bicolored sides of southern Vera Cruz specimens and *copei*. A specimen from Toxtlacuaya has the coloration of *imperialis*, except that the light dorsolateral stripes are broken on the neck and leave a pair of light spots on the nape, as in *copei* and many *clavatus*. The only specimen which shows intermediacy in the width of the middorsal stripe is from Tierra Colorado; in it the dark extends imperfectly onto the paravertebral rows.

In southern Vera Cruz specimens show close approach in coloration to *copei*, but again are closer to *clavatus* in scutellation. The middorsal stripe is usually narrow and continuous, and the sides are often bicolored, as in *copei*, but the paravertebral regions are darker than is typical of that race.

In Campeche and Quintana Roo there is a definitely higher ventral average than elsewhere in the range of *clavatus* (Table VI). This feature of variation is sufficiently pronounced to raise the ventral minus caudal number into the limits of variation more characteristic of *copei* and *imperialis* than of *clavatus* (Table VIII). I have not detected any supporting characters of sufficient constancy to permit taxonomic recognition of this population. The highest subcaudal averages are to be found in British Honduras (Table VII); the

TABLE VI

FREQUENCY DISTRIBUTION OF VENTRAL SCALE NUMBERS IN *CONIOPHANES IMPERIALIS*

Population	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	Mean
Males																										
clavatus																										
Honduras	1	0	0	0	2	1	3	1	0	0	0	0	0	0	0	1	..	..	..	..	..	..	..	..	..	9–122.9
Guatemala–B. H.*	2	0	1	1	3	0	3	1	2	1	1	1	0	0	0	1	..	..	..	..	..	..	..	..	..	17–123.0
Campeche	..	..	..	..	..	..	..	..	..	..	..	..	1	0	1	..	..	..	..	..	..	..	..	..	..	2–130.0
Vera Cruz–Oaxaca	..	..	..	..	..	2	3	2	2	0	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	13–124.7
Totals	3	0	1	1	5	3	9	4	4	1	3	3	1	0	1	2	..	..	..	..	..	..	..	..	..	41–125.2†
copei																										
Oaxaca	..	..	..	..	..	..	..	..	..	..	3	4	12	5	2	6	4	..	..	..	..	..	..	..	..	36–129.9
imperialis																										
Texas–Tamaulipas	..	..	..	..	..	..	..	..	..	..	1	0	1	0	3	0	1	0	0	0	1	..	..	..	..	7–131.3
Females																										
clavatus																										
Honduras	..	..	..	..	1	0	2	0	4	3	7	1	0	2	2	3	..	..	..	..	..	..	..	..	..	25–127.2
Guatemala–B. H.*	..	..	..	..	..	..	..	..	2	0	2	1	1	3	2	2	1	1	1	..	..	..	..	..	..	16–129.9
Campeche–Quin. Roo	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0	2	0	0	0	0	1	1	5–136.8
Vera Cruz–Oaxaca	..	..	..	..	..	..	1	0	1	0	1	1	1	2	1	2	0	1	1	..	..	..	..	..	..	12–129.7
Totals	..	..	..	..	1	0	3	0	7	3	10	3	2	7	5	7	2	2	4	0	0	0	0	1	1	58 130.9†
copei																										
Oaxaca	..	..	..	..	..	..	..	..	..	..	..	1	0	2	0	3	2	3	4	3	3	1	0	0	1	23–134.3
imperialis																										
Texas–Tamaulipas	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0	1	0	1	2		5–138.2

* British Honduras. † Mean of the means.

TABLE VII

FREQUENCY DISTRIBUTION OF SUBCAUDAL SCALE NUMBERS IN *CONIOPHANES IMPERIALIS*

Population	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Mean
Males																															
clavatus																															
Honduras															1	0	1	1													3–80.7
Guatemala–B. H.*											1	0	0	0	0	1	0	0	0	1	2	1	1	1	0	0	0	0	1	1	10–85.7
Vera Cruz–Oaxaca												1	1	2	1	2	1	0	0	1											9–78.2
Totals											1	1	1	2	2	3	2	1	0	2	2	1	1	1	0	0	0	0	1	1	22–81.5†
copei																															
Oaxaca								1	4	2	6	4	7	1	1	1															27–75.5
imperialis																															
Texas–Tamaulipas							1	0	0	1	1	0	1																		4–74.3
Females																															
clavatus																															
Honduras							1	1	3	0	1	2	2	1	1	0	0	0	0	0	1										13–75.8
Guatemala–B. H.*												1	0	2	1	0	3	0	1	1											9–80.1
Campeche–Quintana Roo										1	0	0	1	1	1																4–77.0
Vera Cruz–Oaxaca							1	1	0	0	1	0	0	0	0	1															4–75.5
Totals							1	2	4	1	1	4	3	4	3	0	4	0	1	1	1										30–77.1†
copei																															
Oaxaca	1	2	0	1	2	2	3	0	0	1	1																				13–69.9
imperialis																															
Texas–Tamaulipas				1	0	0	0	1	0	0	0	0	0	1																	3–72.7

* British Honduras. † Mean of the means.

TABLE VIII

FREQUENCY DISTRIBUTION OF VENTRAL MINUS SUBCAUDAL SCALE NUMBERS IN *CONIOPHANES IMPERIALIS*

Population	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	Mean
Males																																															
clavatus																																															
Honduras	..	..	..	..	..	..	..	..	..	1	0	0	0	1	0	0	0	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3 40.0
Guatemala–B. H.*	1	0	1	0	0	0	0	0	1	1	0	1	2	0	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10–36.7
Vera Cruz–Oaxaca	..	..	..	..	..	..	..	..	..	..	..	..	1	0	1	1	1	1	0	0	1	1	1	0	0	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9–45.0
Totals	1	0	1	0	0	0	0	0	1	2	0	1	3	1	3	2	1	2	0	0	1	1	1	0	0	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22–40.6†
copei																																														
Oaxaca	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	3	3	4	3	4	2	6	0	1	..	..	..	..	..	..	..	..	..	..	..	..	..	27–54.0
imperialis																																														
Texas–Tamaulipas	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	0	0	0	1	..	..	..	..	..	..	..	..	..	..	..	..	..	4–56.8
Females																																														
clavatus																																														
Honduras	..	..	..	..	..	..	..	..	..	1	0	0	0	0	0	0	0	0	0	0	2	1	1	1	0	1	1	3	0	0	1	0	0	1	..	..	..	..	..	..	..	..	..	..	..	..	13- 50.8
Guatemala–B. H.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0	0	1	0	0	0	1	0	2	1	2	1	..	..	..	..	1	0	0	0	2	0	0	1	..	..	..	..	..	..	..	9–49.7
Campeche–Quin. Roo	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	0	0	1	0	0	1	..	..	..	..	..	..	..	..	..	..	..	..	..	4–60.8
Vera Cruz–Oaxaca	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4–55.3
Totals	..	..	..	..	..	..	..	..	..	1	0	0	0	0	1	0	0	1	0	0	2	2	1	1	2	2	5	4	0	1	2	0	1	1	2	0	0	1	..	..	..	..	..	..	..	..	30 54.2†
copei																																														
Oaxaca	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0	0	2	1	1	0	2	2	2	0	0	1	0	1	13–64.8
imperialis																																														
Texas–Tamaulipas	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0	0	0	0	0	1	0	0	1	..	3–67.0

* British Honduras. † Mean of the means.

lowest ventral averages, in Honduras (Table VI). Unfortunately insufficient material and a high proportion of incomplete tails have restricted recognition and analysis of significant tendencies in these characters.

A racial comparison of dorsal formulae indicates distinctly different sexual trends in *copei* and the two other subspecies (Table IX).

TABLE IX

Sexual and Racial Variation in Dorsal Scale-Row Formulae in *Coniophanes imperialis*

Subspecies	Males				Females			
	No.	21–19–17	19–17	19–17–15	No.	19–17	19–17–15
imperialis.....	10		20.0%	80.0%	6		100.0%
clavatus.....	34	2.9%	17.7	79.4	55	41.8%	58.2
copei.....	35		60.0	40.0	21	19.1	81.0

With the exception of a single male specimen from Belize (dorsals 21–19–17) the condition obtaining in *clavatus* is the usual one in snakes, with males tending toward greater reduction than females. In *Dromicus hoodensis* (Van Denburgh, 1912 : 340) this dimorphism is complete, females having 19 rows and males 17. Such differences have been explained by maternal requirements for a thicker body. No ready explanation of the greater female reduction in *copei* comes to mind. It might be expected that the race, sex, and individuals with the highest ventral numbers would reduce most; this is true for sex in *copei*, but not in *clavatus*, and no significant individual tendencies can be detected.

The Bebedero, Costa Rica, record for *imperialis* (Wettstein, 1934 : 37) is based on specimens of the recently described *Conophis nevermanni* Dunn, which Dr. Wettstein kindly enabled me to examine. The specimen from Mine Purnio, Colombia, recorded as *imperialis* by Werner (1899 : 4), is certainly not *imperialis*, but may belong to *Rhadinaea* (dorsals 17, ventrals 145, subcaudals 105).

Material examined:

Honduras: Tela (9, MZUM, 58416, 63351, 69393, 63985; MCZ, 31661–62); Tela, Ulúa River (14, MCZ, 19336, 19338, 20213, 20215–25); Progreso District, Ulúa (12, MCZ, 21801–06, 21715–20); Progreso (10, USNM, 62515, 63352; MCZ, 26860–61); Lancetilla (2, ANSP, no no.; MZUM,

69534); Los Indios* (1, MCZ, 38759); Garcia Plantation, Ulúa River* (4, MZUM, 62516); Guaymas District* (11, MZUM, 62525, 63353); Hicaque Farm* (1, MZUM, 63354).

Guatemala: (1, USNM, 6758); Petén (1, USNM, 71783); La Libertad, Petén (4, MZUM, 74889–92); Uaxactún, Petén (1, MZUM, 70452); Quiriguá (1, FMNH, 20543); Puerto Barrios (2, FMNH, 20583–84).

British Honduras: (8, FMNH, 4238–45); Belize (4, USNM, 26355, 26064; FMNH, 4444–45); Manatee River, Belize (1, FMNH, 5825); Stann Creek (1, USNM, 50623).

Mexico: Campeche: Champotón (1, MZUM, 73067); Balchacaj (5, HMS, 1490, 1517, 1677, 1700, 1711). Quintana Roo: near Catmis (1, FMNH, 27002). Vera Cruz: Mandinga* (AMNH, 19613); Estación Forestal* (1, AMNH, 19781); Cuatotolapam (2, MZUM, 41557–58); Vera Cruz (2, ANSP, 4869–70); Potrero Viejo, near Cordoba (2, EHT, 5208–09); Tierra Colorado, 20 kilometers west of Vera Cruz (1, EHT, 4562); Cerro del Gallo, southern Vera Cruz (4, MCZ, 16108–11). Oaxaca (intergrades with *clavatus*): (5, AMNH, 19790–92, 22738, 19613). Mexico? (3, ANSP, 3483–85).

Coniophanes imperialis copei Hartweg and Oliver

(Pl. I, Fig. 3; Pl. III, Fig. 3; distributional map, Fig. 5)

Erythrolamprus imperialis Boulenger, 1896: 206 (part).
Coniophanes imperialis copei Hartweg and Oliver, 1938: 4–6; 1939.

Holotype. — MZUM, 82666, adult male, between Quiengola Mountain and Tehuantepec, collected by Hartweg and Oliver.

Range. — West coast of Oaxaca, intergrading with *clavatus* in southern Vera Cruz.

Diagnosis. — A *Coniophanes* with 19 scale rows; bifurcate, spineless hemipenis; light temporal stripe present; a continuous middorsal dark stripe one third of a scale wide; sides distinctly darker above than below; ventrals minus caudals, males over 49, females usually over 60.

Description. — Dorsals 19–17 or 19–15; ventrals, males 127–133, females 128–141; subcaudals, males 72–80, females 65–75; ventrals minus subcaudals, males 50–59, females 58–72 (usually over 60). Upper labials 8, fourth and fifth in eye; lower labials 9 or 10, 5 or 6 in contact with chin shields. Oculars 1 (2)–2; temporals 1–2. Dentition and hemipenis as in *imperialis*. The everted hemipenis is inflated laterally immediately below the fork; these lateral inflations appear as laminae when the organ is not everted; the tips of the forks are smooth but without discs.

Dorsal ground color light tan to brown, with almost no darker punctulations. A fine black line is present on the median third

of the middorsal row. The sides shade from the outer tips of the ventrals to the middle of the fifth row (fourth posteriorly), but are decidedly darker on the upper half. Distinct temporal light stripes present. Yellow nape spots 2 or 3 scales behind the parietals are usually not connected with the dorsolateral light regions, which begin 5 to 6 scales behind the parietals. These are yellow anteriorly but soon widen and darken, remaining lightest along the upper border of the lateral dark band. Labials and throat with scattered black specks; venter otherwise immaculate.

Variation and intergradation are discussed under *clavatus* (p. 37).

Undoubtedly some of Cope's records for *proterops* included this form and *clavatus copei* intergrades in part, but without designated specimens they cannot be definitely allocated.

Material examined. — Vicinity of Tehuantepec, Oaxaca (56, MZUM, 82666 82721, holotype and paratypes); Tehuantepec (1, USNM, 30299; 1, BM, 71.2.7.33); Laguna Colorado, road to Santiago, Oaxaca (1, AMNH, 19740).

Coniophanes meridanus Schmidt and Andrews

(Distributional map, Fig. 5)

Coniophanes meridanus Schmidt and Andrews, 1936 : 179–80; Andrews, 1937 : 356.

Holotype. — FMNH, 19427, female, Mérida, Yucatan, collected by E. Wyllys Andrews.

Range. — Known only from the type locality.

Diagnosis. — A *Coniophanes* with 17 scale rows; usually 7 upper labials; bifurcate spineless hemipenis; light temporal stripe present; body lacking stripes, reddish in life; a distinctive nape pattern.

Description. — The third and fourth upper labials enter the eye (fourth and fifth when 8 are present). Oculars and temporals 1–2. Maxillary teeth 10 followed by a gap and 2 enlarged grooved fangs. Hemipenis (27,000) 11 caudals long, forked opposite seventh; like that of *imperialis*, except that the calyces appear even larger (but equally shallow).

The body is unicolor dorsally, reddish in life, with very slight traces of the generalized striping anteriorly. The head has the light temporal stripes characteristic of the *imperialis* group, but they follow the parietal edges more closely; in one specimen they are separated by three dorsal scales from being confluent with one

another around the parietals. Anteriorly there is a trace of a mid-dorsal stripe which extends to the parietals. Two scales back of the parietals there is an incomplete black collar about 2 scales deep on the mid-line, the lower tips of which extend posteriorly for a short distance. This pattern is homologous with that portion of the *imperialis* pattern which separates the nape spots from the dorso-lateral light stripes. In *meridanus* the nape spots are continuous laterally and lateroventrally with the ground color of the body. The lower posterior projections of the collar represent the upper anterior portion of the lateral dark stripe of *imperialis*. The sides of the neck and the labials bear a few scattered dark specks, and the venter is immaculate, except that two specimens have irregularly arranged black pigment on the ventral surface of the tail.

In dorsal and labial scutellation, color pattern, and size *meridanus* is a degenerate form of *imperialis*. Its only recent discovery in a rather well known region, and its scarcity in collections may be indicative of more secretive habits than most of its congeners.

Data for material examined (all from Mérida):

Museum no.	*Sex*	*Dorsals*	*Ventrals*	*Caudals*	*Upper labials*	*Body length*	*Tail length*	
FMNH, 27000	♂	17–15	123	..	7	..	..	
26998	♂	17–13	122	83	7	98	48	
26999	♂	15–17–15	122	87	..	92	46	
27001	♀	17–15	134	85	7	broken	..	
19427	♀	17–15	132	..	7/8	313	..	Type

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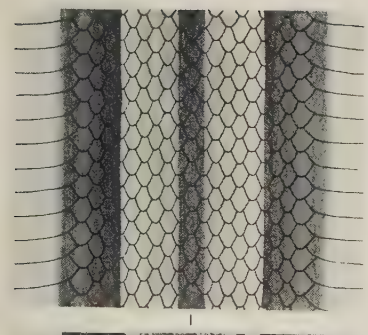
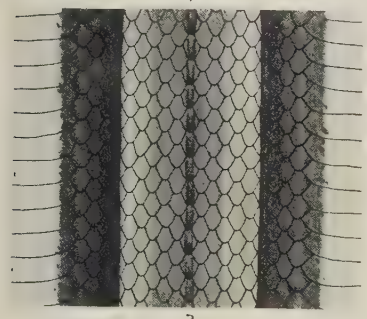
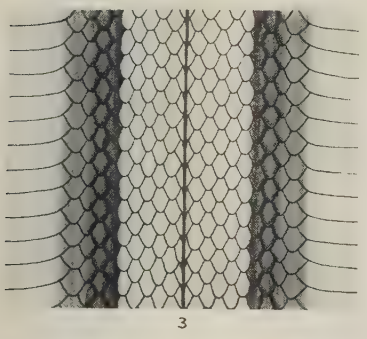
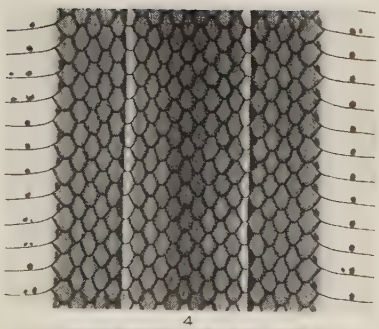
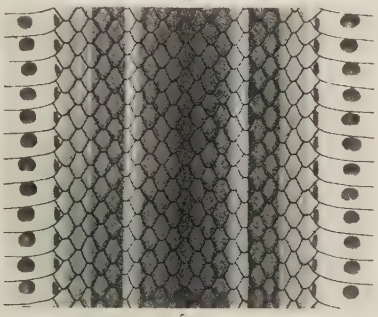










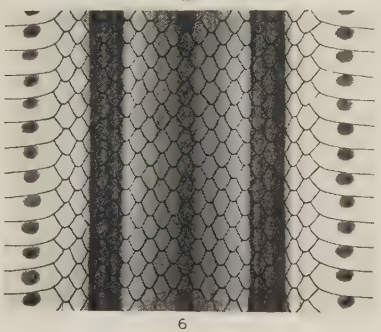
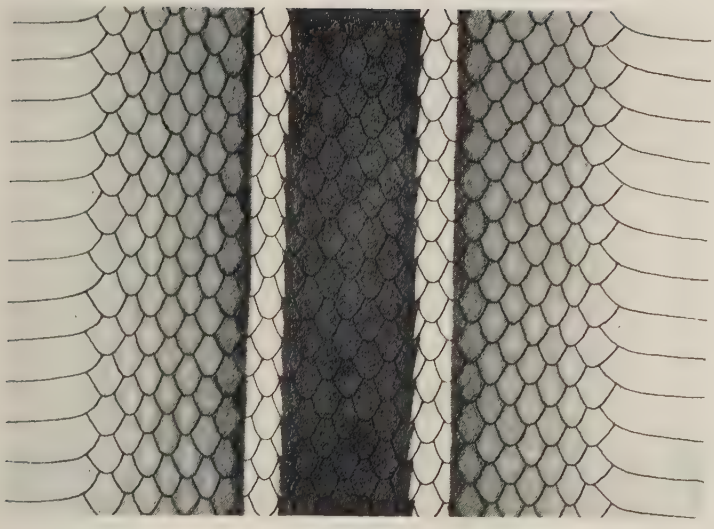


Fig. 1. *Coniophanes i. imperialis*, MZUM, 75816, male, Brownsville, Texas
Fig. 2. *C. i. clavatus*, MZUM, 63351, female, Tela, Honduras
Fig. 3. *C. i. copei*, MZUM, 82666, holotype male, Tehuantepec, Mexico
Fig. 4. *C. f. fissidens*, MZUM, 74431, male, Tela, Honduras
Fig. 5. *C. bipunctatus*, FMNH, 20578, male, Puerto Barrios, Guatemala
Fig. 6. *C. quinquevittatus*, MZUM, 79060, female, Flores, Guatemala



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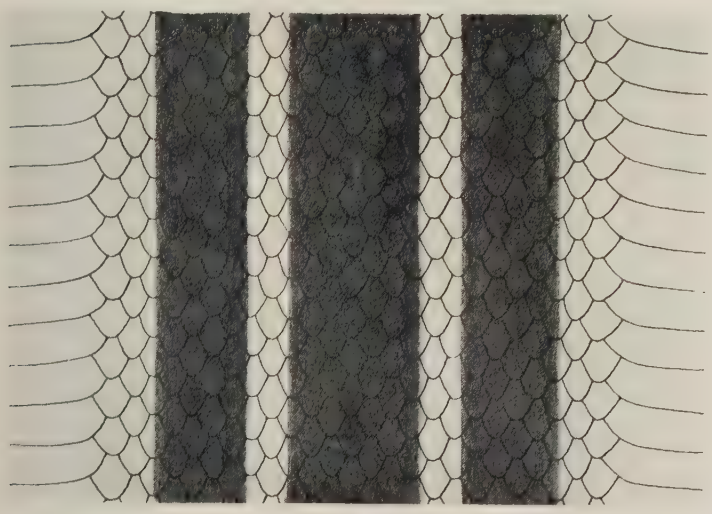

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FIG. 1. *Coniophanes schmidti*, MZUM, 73043, holotype male, Chichen Itza, Yucatan

FIG. 2. *C. piceivittis*, MZUM, 82904, male, Copan, Honduras

FIG. 1. *fissidens fissidens* FIG. 2. *schmidti* FIG. 3. *imperialis copei*

REPRESENTATIVE HEMIPENES OF *CONIOPHANES*

Everted. MZUM, 57964 Dissected out. MZUM, 73039 Everted. MZUM, 82682

ANYPHAENIDAE AND CLUBIONIDAE OF MICHIGAN

ARTHUR M. CHICKERING

DURING the past ten years I have been engaged in the collection and study of the spiders of Michigan. My specimens are now regarded as sufficiently representative to warrant a comprehensive treatment of the different families at present known to occur in the state. It is hoped that this paper and others planned to appear subsequently will aid teachers and students of biology, nature study, and similar subjects to become acquainted with the members of this division of our fauna.

Measurements of the bodies of these animals are taken from the anterior border of the cephalothorax to the tip of the anal tubercle or postabdomen. Thus in an animal with porrect chelicerae the length of the body as reported here might appear to be much less than it would with other limits of measurement. In descriptions of the teeth along the margins of the fang groove the first is always the most medial and the farthest from the base of the fang. The color as described in this paper is that of the specimens in alcohol.

It is generally necessary to clear away the hairs surrounding the epigynum in order to see the minute structure of this organ. A small long-handled camel's-hair brush cut down to a stiff stump is used for this purpose.

Although the teeth which usually lie along either side of the fang groove are of some value in determining species, this feature must be used with caution because of the variation in the number and the relative size of these organs.

Clubionidae not hitherto reported in faunal lists for Michigan include the following species: *Clubiona agrestis* Emerton, *C. moesta* Banks, *C. obtusa* Emerton, *Phrurolithus borealis* Emerton, and *P. formidabilis* (Chamberlin and Gertsch).

No attempt has been made to supply a complete synonymy in

this article. Only what I have considered to be the essential synonymy has been included.

It is with a great deal of pleasure that I acknowledge the help and encouragement of Mr. Nathan Banks and Miss Elizabeth B. Bryant, both of the Museum of Comparative Zoölogy, Harvard University, in the preparation of this paper. During the summer of 1937 I was able to compare my specimens of the two families treated here with those in the collection of that museum. Otherwise, progress would have been difficult or impossible. Miss Bryant also very kindly loaned me valuable specimens for detailed study and supplied me with a drawing of the epigynum of *C. obtusa*.

The Anyphaenidae and the Clubionidae, often included in the same family, may be separated easily as follows:

1. Tracheal spiracle near the base of the spinnerets as in the majority of our spiders ..... Clubionidae, p. 54
1. Tracheal spiracle remote from the base of the spinnerets, usually about midway between these and the genital furrow ..... Anyphaenidae, p. 50

ANYPHAENIDAE

KEY TO THE GENERA OF ANYPHAENIDAE

1. AME nearly as large as ALE; in males embolus makes almost a complete circle; in females epigynum is nearly circular and margined; maxillary lobes concave midway along outer border *Aysha gracilis*, p. 53
1. AME distinctly smaller than ALE; in males embolus does not make nearly a circle; in females epigynum is not almost circular and is not margined ..... *Anyphaena*, p. 50

Genus ANYPHAENA Sundevall, 1833

KEY TO THE SPECIES OF *ANYPHAENA*

MALES

1. Palpal tibial apophysis very large and bifurcated, one branch an elongated spur, the other saddle-shaped; chelicerae usually with five stout teeth on promargin of fang groove and eight small teeth on retromargin *Anyphaena celer*, p. 51
1. Palpal tibial apophysis not very large and not bifurcated; instead there are two obscure processes, one is a long, low ridge distally placed; fang groove usually with four stout teeth on promargin and six small teeth on retromargin ..... *A. pectorosa*, p. 51

FEMALES

1. Epigynum with a central prominent raised wedge-shaped area; fang groove usually with five stout teeth on promargin and eight small teeth on retromargin ..... *A. celer*, p. 51
1. Epigynum without a central prominent raised wedge-shaped area, but with two small somewhat curved lobes near posterior margin; fang groove usually with four stout teeth on promargin and six small teeth on retromargin ..... *A. pectorosa*, p. 51

Anyphaena celer (Hentz)

Clubiona celer Hentz, 1847.
Anyphaena incerta Keyserling, 1887.
A. incerta Emerton, 1889.
Gayenna celer Comstock, 1913.

(Figures 1–4, p. 52)

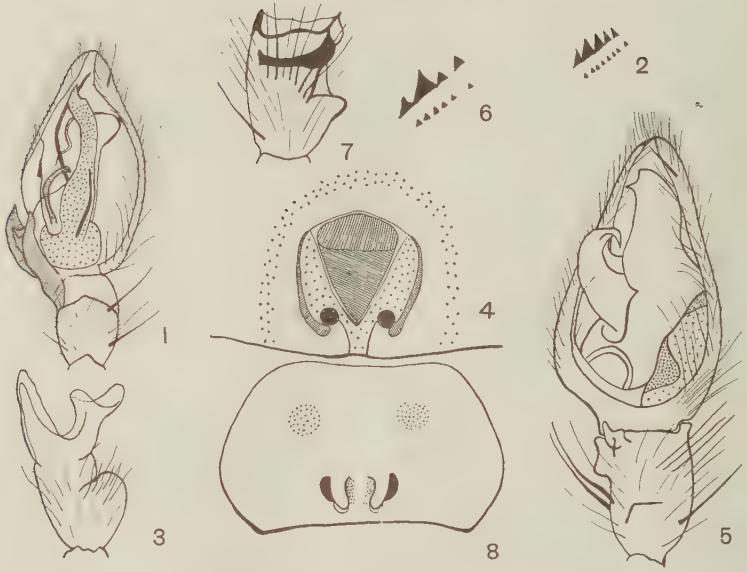
This appears to be a common species in the southern part of the state, where it has been collected many times in the débris from the forest floor, especially in damp places. Males are about 4.25 mm. long and females are a little more than 5 mm. long. In both sexes the legs are yellowish with faint darker spots; spots are quite dark in some individuals. The cephalothorax has a narrow dark stripe along the margin and a broad dark stripe much broken along each side. The abdomen is yellowish, with many darker spots dorsally and smaller ones ventrally. The male palpal tibial apophysis is very prominent and characteristically divided into a long dorsal spur and a ventral shorter, broader, somewhat saddle-shaped structure (Figs. 1, 3). The epigynum, also, is very prominent and distinctive. Its central portion is a raised wedge-shaped area (Fig. 4). The promargin of the fang groove usually bears five teeth, but in some individuals only four occur. The retromargin generally has eight small teeth, but this number, also, is variable (Fig. 2).

Anyphaena pectorosa L. Koch

Anyphaena calcarata Emerton, 1890.
Gayenna calcarata Banks, 1910.
G. pectorosa Comstock, 1913.

(Figures 5–8, p. 52)

Though less common than the preceding species this spider seems to occur rather frequently in the southern part of the state in about



EXTERNAL ANATOMY OF SPIDERS

(Figures 1–8)

1. *Anyphaena celer*, right male palpus, ventral view
2. *A. celer*, left cheliceral teeth
3. *A. celer*, right male palpal tibia, retrolateral view
4. *A. celer*, epigynum
5. *Anyphaena pectorosa*, right male palpus, ventral view
6. *A. pectorosa*, left cheliceral teeth
7. *A. pectorosa*, right male palpal tibia, retrolateral view
8. *A. pectorosa*, epigynum

the same type of habitat. Males are about 5 mm. long and females about 5.5 mm. The general color of the body and appendages is approximately the same as in *Anyphaena celer*, but the darker spots are somewhat less numerous. In females the broad lateral stripes on the cephalothorax are a little more prominent and in males they are less prominent than in the preceding species. The palpal tibial apophysis in the male is much less conspicuous than in *A. celer* and is divided into a short somewhat pointed ventral process and a long dorsal ridge (Figs. 5, 7). The epigynum is much wider than long

and possesses a pair of curved central lobes surrounding a small depression (Fig. 8). The promargin of the fang groove is armed with four fairly stout teeth, the second of which is the largest. The retromargin of the fang groove bears six small teeth (Fig. 6). The number and arrangement of teeth seems to be fairly constant in this species, but some variation may be expected. In males there is a stout spur at the proximal end of the ventral side of the fourth coxae. Extending from about the middle of the ventral surface of the third coxae are two processes; the anterior one is blunt, the posterior one is pointed and bifurcated.

Genus AYSHA Keyserling, 1891

Aysha gracilis (Hentz)

Clubiona gracilis Hentz, 1847.
Anyphaena rubra Emerton, 1890.
Aysha orlandensis Tullgren, 1901.
Anyphaena gracilis Banks, 1904.
Aysha gracilis Bryant, 1931.

(Figures 9–11, p. 55)

Aysha gracilis seems to be the least common of the three species of Anyphaenidae now known to occur in Michigan and, like the other two species, it has been taken only in the southern part of the state. Males are about 6.5 mm. long when mature. In both sexes the legs are yellowish, but they shade toward an amber color. The chelicerae tend to be a deep reddish brown. The body is generally yellowish with a pair of faint grayish dorsolateral stripes on the cephalothorax and numerous reddish brown spots all over the dorsum of the abdomen except for a lanceolate stripe at the base which is nearly free of color. The venter has few or no reddish brown spots. The tibial apophysis is a single long retrolateral terminal spur. The embolus is in the form of a long sweeping circular curve quite characteristic of this genus (Fig. 9). The epigynum has a low dome-shaped outline with a distinct chitinous margin which also seems to be generic (Fig. 11). In the male the promargin of the fang groove has four teeth and the retromargin has seven (Fig. 10). In the female the number and arrangement of the teeth are approximately the same as in the male.

CLUBIONIDAE

KEY TO THE GENERA OF CLUBIONIDAE

1. Posterior row of eyes strongly recurved; first and second pairs of legs much stouter than third and fourth pairs; all legs devoid of spines *Trachelas*, p. 82
1. Posterior row of eyes either straight or procurved; first and second pairs of legs not much stouter than third and fourth pairs; all legs usually with numerous spines 2
2. Five or six pairs of prominent ventral movable spines on first and second tibiae; prominent convex sternum continued far between posterior coxae ..... *Phrurolithus*, p. 78
2. Usually only two or three pairs of less prominent ventral spines or a double row of numerous weak ventral spines on first and second tibiae; sternum not so convex and does not extend so far between posterior coxae 3
3. Posterior row of eyes nearly straight; seen from in front, anterior row of eyes also straight; width of clypeus less than diameter of AME *Clubiona*, p. 61
3. Posterior row of eyes distinctly procurved; seen from in front, anterior row of eyes also distinctly procurved; width of clypeus more than diameter of AME 4
4. First tibiae with two rows of numerous short weak ventral spines; abdomen with iridescent scales; median thoracic furrow faint or lacking *Micaria*, p. 76
4. First tibiae with two or three pairs of strong ventral spines; no iridescent scales on abdomen; median thoracic furrow distinct 5
5. First tibiae with three pairs of ventral spines, distal pair terminal (variable); first metatarsi with two pairs of ventral spines, none terminal; white plumose hairs common on body and appendages; clypeus about three times as wide as diameter of AME ..... *Castianeira*, p. 57
5. First tibiae with two pairs of ventral spines, none terminal; first metatarsi with three pairs of ventral spines; white plumose hairs uncommon on body and appendages; clypeus only a little wider than diameter of AME ..... *Agroeca*, p. 54

Genus AGROECA Westring, 1861

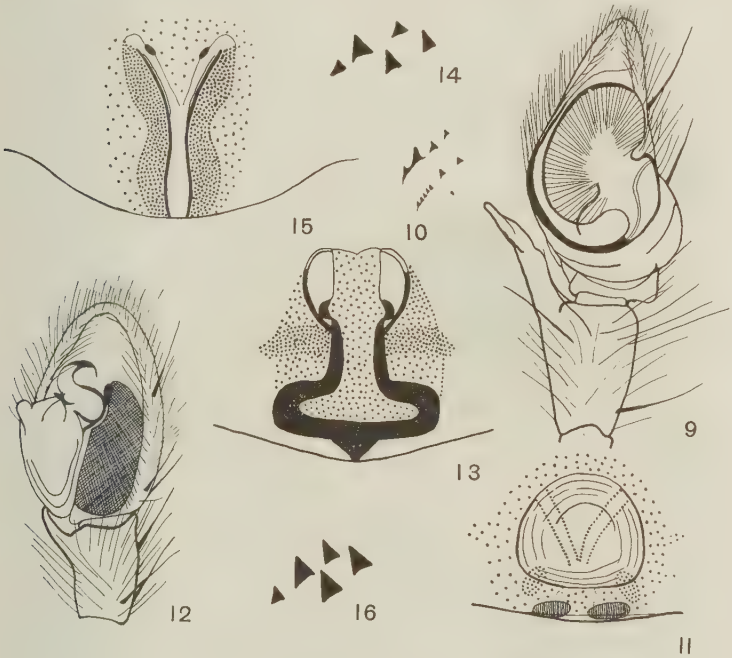
KEY TO THE SPECIES OF *AGROECA*

FEMALES

1. Central chitinized ridges of epigynum diverge posteriorly near the genital furrow to form a prominent transverse arm ..... *Agroeca ornata*, p. 56
Central chitinized ridges of epigynum continue to genital furrow without forming a transverse arm ..... *A. pratensis*, p. 56

MALES

Until very recently the male of *Agroeca ornata* was unknown; I have not taken a male of *A. pratensis* in Michigan. Miss E. B. Bryant kindly loaned me a specimen of *A. pratensis* from Massachusetts, from which I have drawn a figure of the palpus (Fig. 12). By private correspondence I have recently been informed that Dr. W. J. Gertsch, of the American Museum, has differentiated the males of *A. ornata* and *A. pratensis*, but I am unable to state these differences.



EXTERNAL ANATOMY OF SPIDERS

(Figures 9–16)

9. *Aysha gracilis*, male palpus, ventral view
10. *A. gracilis*, left cheliceral teeth
11. *A. gracilis*, epigynum
12. *Agroeca pratensis*, right male palpus, ventral view
13. *A. pratensis*, epigynum
14. *A. pratensis*, left cheliceral teeth
15. *Agroeca ornata*, epigynum
16. *A. ornata*, left cheliceral teeth

Agroeca ornata Banks

Agroeca repens Emerton, 1894.

(Figures 15–16, p. 55)

Only three individuals of this species have been taken in Michigan; they came from Marquette in the Northern Peninsula; all are females; the male is at present unknown to me. The length of these specimens ranges from 5 to 6.6 mm. The species occurs among dead leaves and other débris. The appendages are an amber color. The cephalothorax is amber-colored and has a dark marginal line and radiating dark lines and streaks arranged in a broken stripe on each dorsolateral side. The abdomen has a yellowish background, with many flecks and larger spots of reddish brown, which are fused into an indefinite central stripe from base to spinnerets. Ventrolaterally the reddish brown spots are less numerous. Along the middle of the venter are three more or less distinct narrow stripes, which may unite to form a single broad stripe. The epigynum (Fig. 15) is much longer than wide and consists essentially of two long strips of chitinized material closest together in the middle. The promargin of the fang groove has three stout teeth, whereas the retromargin has only two (Fig. 16).

Agroeca pratensis Emerton

(Figures 12–14, p. 55)

A single female from Marquette constitutes my only record of this species from Michigan. Miss E. B. Bryant very kindly loaned me a male from Massachusetts, from which a figure of its palpus has been drawn. The species occurs in the same type of habitat as the preceding species. The color is much like that of *Agroeca ornata*, except that there are fewer reddish brown markings and the central dorsal abdominal stripe is much less evident. The epigynum (Fig. 13) is more elaborate than it is in *A. ornata*, with a conspicuous crossarm near the posterior border. The promargin of the fang groove has three teeth, the retromargin two (Fig. 14). The tibial apophysis (Fig. 12) of the male palpus is a simple retrolateral terminal spur, and the tarsus is broad and stout. It was suggested by Mr. Emerton that, since only one kind of male had ever been found and both kinds of females had been taken with the single type of male, we have here a case of two forms of females in the species. This doubt has apparently been cleared up by Dr. Gertsch's work, to which reference has already been made.

Genus CASTIANEIRA Keyserling, 1879

KEY TO THE SPECIES OF *CASTIANEIRA*

1. Both sexes with two narrow, light-colored girdles around anterior half of abdomen, incomplete ventrally; all femora more or less striped with dark brown or black; male palpus with an embolus bearing terminal spines; epigynum with a median lobe near posterior margin and openings obscure ..... *Castianeira cingulata*, p. 57
1. Abdomen not provided with two narrow, light-colored girdles; femora not striped with brown or black; male palpi and epigynum not as above 2

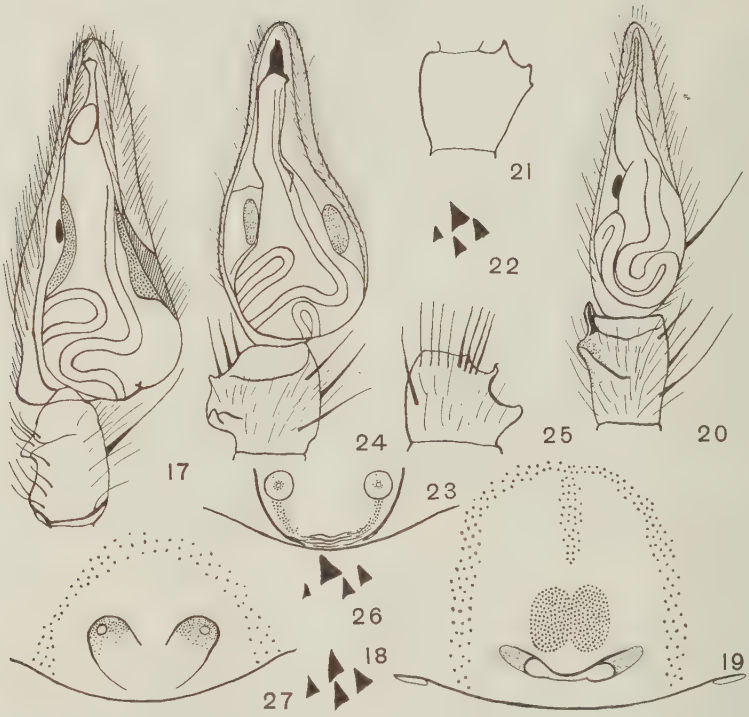
2. Abdomen usually with a dorsal reddish spot above the spinnerets that varies in size and is sometimes broken into several pieces, often with a dorsal lighter spot near the base provided with a variable number of more or less white hairs; femora all dark; epigynum with two small openings between two and three diameters apart; male palpus with an embolus terminating in a slender smooth extension ... *C. descripta*, p. 59
2. Abdomen with several narrow whitish bands of plumose hairs (bands are variable and often broken into patches); femora all dark with patches of white plumose hairs; epigynum with two rather prominent openings connected by a shallow groove; male palpus with an embolus terminating in a short stout spine with bristles at the tip *C. longipalpus*, p. 60

Castianeira cingulata (C. Koch)

Corinna cingulata C. Koch, 1842.
Herpyllus zonarius Hentz, 1847.
Sparassus cingulatus Walckenaer, 1847.
Castianeira bivittata Keyserling, 1887.
Geotrecha bivittata Emerton, 1890.
Thargalia bivittata Banks, 1892.
Castianeira cingulata Petrunkevitch, 1911.

(Figures 17–19, p. 58)

Castianeira cingulata appears to be fairly common in the Southern Peninsula of Michigan, where all my specimens have been collected from forest litter, beneath logs and stones, and among leaves on the ground. Adult females are about 7.4 mm. long; adult males are about 6.75 mm. long and somewhat more slender than the females. The general body color is a rich mahogany brown. Dorsally the abdomen has a pair of narrow whitish transverse bands incomplete ventrally; one is near the middle and the other is about halfway from there to the base. The first coxae are brown; all others are yellowish. All femora are prominently striped with dark brown and



EXTERNAL ANATOMY OF SPIDERS

(Figures 17–27)

17. *Castianeira cingulata*, right male palpus, ventral view
18. *C. cingulata*, left cheliceral teeth
19. *C. cingulata*, epigynum
20. *Castianeira descripta*, right male palpus, ventral view
21. *C. descripta*, right male tibia, dorsal view
22. *C. descripta*, left cheliceral teeth
23. *C. descripta*, epigynum
24. *Castianeira longipalpus*, right male palpus, ventral view
25. *C. longipalpus*, male palpal tibia, dorsal view
26. *C. longipalpus*, left cheliceral teeth
27. *C. longipalpus*, epigynum

with a yellowish color. The first two pairs of tibiae are yellowish; the last two are striped like the femora. The tibial apophysis (Fig. 17) is a low retrolateral ridge extending from near the proximal end to near the distal end, where it is produced into a low process. The embolus is stout near the tip, which is dilated and provided with spines. The epigynum (Fig. 19) is a convex plate with a procurved groove a little in front of the genital furrow. A short blunt tongue extends over a portion of the groove. Each margin of the fang groove (Fig. 18) of the chelicera is armed with two strong teeth.

Castianeira descripta (Hentz)

Herpyllus descriptus Hentz, 1847.
H. crocatus Hentz, 1847.
Geotrecha crocata Emerton, 1890.
Thargalia crocata Banks, 1892.
T. fallax Banks, 1892.
Castianeira descripta Simon, 1898.

(Figures 20–23, p. 58)

This species seems to be somewhat more common in Michigan than the preceding one. All my specimens are from the Southern Peninsula, where the species lives under much the same conditions as *Castianeira cingulata*. During the summer of 1937 I found it very numerous along the shore of Lake Michigan among the drift débris near Cross Village. Adult females average about 8.3 mm. long, whereas adult males are about 6.6 mm. long. The general body color is a deep reddish brown, usually with a large reddish spot of irregular outline on the dorsal side of the abdomen behind the middle. There may be additional smaller reddish spots in front of the large one. Frequently there are whitish spots, also, made by an aggregation of plumose white hairs; these may occur on the cephalothorax and legs as well. All coxae, trochanters, and femora are dark brown without stripes. The remaining segments are yellowish in the first two pairs of legs and much darker in the last two pairs. The tibial apophysis (Figs. 20 21) in the male is a retrolateral blade with two short extensions. The embolus has a moderately long and slender tip without terminal dilation and without terminal spines. The epigynum (Fig. 23) is a chitinized plate with two openings about 2.5 diameters apart and about 1.5 diameters from the genital furrow. Each margin of the fang groove (Fig. 22) is armed with

two teeth; the first tooth on the promargin is much smaller than the second one.

Castianeira longipalpus (Hentz)

Herpyllus longipalpus Hentz, 1847.
Geotrecha pinnata Emerton, 1890.
Thargalia perplexa Banks, 1892.
T. pinnata Banks, 1893.
Castianeira pinnata Bryant, 1908.
C. longipalpus Banks, 1910.

(Figures 24–27, p. 58)

The small number of these animals in my collections indicates that it is the least common of the three species of *Castianeira* known to occur in Michigan. As with the other species of this genus, *C. longipalpus* has been taken only in the Southern Peninsula and frequents the same localities as do *C. descripta* and *C. cingulata.* Adult females are about 8.2 mm. long, adult males about 5.75 mm. long. The general color of the body is a dark reddish brown. White plumose hairs are scattered irregularly over the cephalothorax, but are easily rubbed off and thus often go unnoticed. Dorsally the abdomen has a series of seven or more white transverse bands made of plumose hairs. Since these are easily removed in handling they are usually regarded as quite variable in occurrence and extent. The first three segments of all legs are dark brown. The remaining segments on each of the first two pairs of legs are yellowish, but the same segments on the last two pairs of legs are much darker. All femora are more or less banded with white plumose hairs. The male tibial apophysis (Figs. 24 25) is a retrolateral blade with two extensions; these are somewhat longer than in either of the other two species of this genus. The embolus is suddenly narrowed near the tip, which is not dilated but has some irregularities. The epigynum (Fig. 27) is a chitinized plate shallowly grooved a little in front of the genital furrow and with two large openings slightly more than their diameter apart. The promargin of the fang groove (Fig. 26) has two teeth; the first is rather small, the second large. The retromargin of the fang groove has two teeth of medium size.

Genus CLUBIONA Latreille, 1804

KEY TO THE SPECIES OF *CLUBIONA*

MALES

1. Palpal tibia, exclusive of tibial apophysis, much longer than wide; abdomen well marked dorsally with black or dark brown bars and usually a median dark basal stripe ..... *Clubiona pallens*, p. 71
1. Palpal tibia, exclusive of tibial apophysis, not much longer than wide and usually distinctly wider than long; abdomen not well marked dorsally with black or dark brown bars and a dark basal stripe 2
2. Palpal tibial apophysis a single stout process terminating in a hook turned toward the tarsus 3
2. Palpal tibial apophysis not a single stout process terminating in a hook turned toward the tarsus 4
3. Palpal tibial hook shorter, blunter, and near the apex turned at a right angle toward the tarsus; chelicerae a dark brown color with basal segment considerably produced and excavated dorsally and distally *C. mixta*, p. 67
3. Palpal tibial hook longer and slenderer and near the apex not turned toward the tarsus at a right angle; chelicerae not a dark brown color and basal segment not much produced or much excavated dorsally and distally ..... *C. obesa*, p. 69
4. Palpal tibia, including the lateral apophysis, divided dorsally into a large elaborate tripartite structure ..... *C. tibialis*, p. 74
4. Palpal tibia not divided dorsally into a large elaborate tripartite structure 5
5. Promargin of fang groove with only two large teeth and two small ones; retromargin of fang groove with no teeth, but with a low keel; clypeus only about one fourth of diameter of AME; tibial apophysis a flat spoonlike process overlapping the tarsus without prominent lobes, gently curved distally ..... *C. obtusa*, p. 71
5. Promargin of fang groove without two large and two very minute teeth; retromargin of fang groove always with two or more teeth and no low keel; clypeus one third of diameter of AME or more; tibial apophysis not simple, spatulate, without lobes 6
6. Palpal tibial apophysis divided into two short dorsal lobes and a longer curved ventral process; a distinct reddish brown central basal abdominal stripe followed by a series of middorsal spots to spinnerets; distal half of palpal tarsus broadened ..... *C. riparia*, p. 73
6. Palpal tibial apophysis not divided into two short dorsal lobes and a longer curved ventral process; reddish brown markings on dorsum of abdomen poorly developed or lacking; distal half of palpal tarsus not broadened 7
7. Palpal, tibial apophysis divided into an elongated ventral process like an arrow point with a notch, and a much shorter thinner dorsal process; a faint central basal dorsal abdominal lanceolate stripe with a series of faint light-colored recurved bars posterior to it *C. canadensis*, p. 65
7. Palpal tibial apophysis and body markings not as indicated above..... 8

8. Palpal tibial apophysis with two slender hooks bent toward the tarsus; promargin of fang groove usually with four teeth; retromargin of fang groove usually with three teeth ..... *C. agrestis*, p. 65
8. Palpal tibial apophysis without two slender hooks bent toward the tarsus; promargin of fang groove usually with five teeth; retromargin of fang groove usually with four teeth 9

9. Palpal tibial apophysis massive, divided medially, ventral half with two short, terminal points; palpal patella with a short ventral terminal process ..... *C. abboti*, p. 63
9. Palpal tibial apophysis a broad thin bladelike extension; palpal patella without a ventral terminal process ..... *C. moesta*, p. 68

FEMALES

1. Epigynum much longer than wide, with a free tongue about twice as long as wide; abdomen with several black or dark brown dorsal bars and stripes ..... *C. pallens*, p. 71
1. Epigynum as wide as or wider than long, without a free tongue twice as long as wide; abdomen without black or dark brown dorsal bars or stripes 2

2. Epigynum with a pronounced notch, triangular in form, in middle of posterior border, in front of which are two small irregular openings about a diameter apart; generally yellowish in alcohol and usually with a reddish brown, dorsal basal lanceolate stripe on abdomen; promargin of fang groove with five teeth; retromargin of fang groove with four teeth; a smaller species, usually about 4 mm. long *C. abboti*, p. 63
2. Not with combination of characters given above 3

3. Epigynum with a shallow notch in middle of posterior border, in front of which are two irregularly excavated regions; openings to seminal receptacles are more than two diameters apart; generally reddish brown; promargin of fang groove with three teeth; a larger species, about 7.5 mm. long ..... *C. agrestis*, p. 65
3. Epigynum not as above and lacking combination of characters given above 4

4. Epigynum with three more or less prominent lobes along posterior border and two prominent posterolateral openings placed obliquely; promargin of fang groove with six teeth; retromargin of fang groove with four teeth; a larger species, about 10 to 11 mm. long *C. obesa*, p. 69
4. Not with epigynum as above and not with combination of characters given above 5

5. Epigynum with a single large opening near posterior border; within large median opening is a pair of small apertures; posterior margin of epigynum with a single median slightly developed lobe 9
5. Combination of characters not as above 6

6. Epigynum with a prominent lobe in middle of posterior border and a smaller and pointed lobe on each side; just in front of central lobe is a

depressed area with two small openings nearly at right angles to the surface; promargin of fang groove with six teeth; retromargin of fang groove with five teeth, three forming a tridentate structure
C. moesta, p. 68

6. Not with combination of characters given above 7

7. Epigynum with a small central lobe along posterior border, with a large, rounded lobe notched posteriorly on each side; main part of epigynum consists of a central swollen area with an oblique groove on each side and a curved ridge bordering the groove; no external openings apparent in epigynum; promargin of fang groove with four teeth; a large species about 8 mm. long ..... *C. tibialis*, p. 74

7. Not with combination of characters given above 8

8. Epigynum with a central notch in posterior border; each side of notch is a prominent unchitinized yellowish lobe; a central septum separates light-colored unchitinized lobes and overhangs an irregular opening about as wide as septum; sometimes septum divides the opening into two; promargin of fang groove with five teeth; retromargin of fang groove with four teeth ..... *C. riparia*, p. 73

8. Epigynum with a central swollen somewhat bulbous septum separating two light-colored slightly chitinized areas; dorsal to central septum is a broad plate forming a central lobe with a recurved margin visible only when viewed from behind or when organ is turned outward
C. canadensis, p. 65

9. External openings of epigynum about one third their diameter from posterior margin; spermathecae separated by their diameter
C. obtusa, p. 71

9. External openings of epigynum almost touching posterior margin; spermathecae separated by less than one third their diameter
C. pygmaea, p. 73

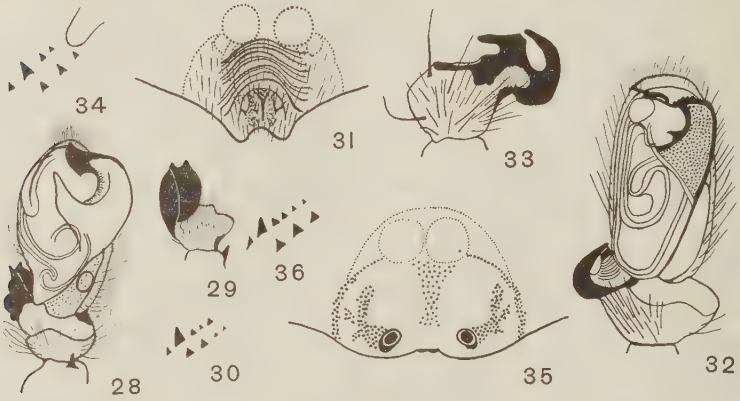
Clubiona abboti L. Koch

Clubiona rubra Keyserling, 1887.
C. rubra Emerton, 1889.
C. abboti Banks, 1892.

(Figures 28–31, p. 64)

This is one of the smallest members of the genus and is, apparently, the most common of our Michigan *Clubionae*. I have taken the species only once in the Northern Peninsula, at Grand Marais. Adult females are about 4 mm. long and adult males about 3.6 mm. long. The cephalothorax and legs are yellowish. Typically the abdomen is a lighter yellow with a bright reddish brown median dorsal lanceolate stripe near the base and a spot of similar color that has irregular outlines and is more or less mottled covering the posterior third or half of the dorsal surface. There is a great variation, how-

ever, in the degree and extent of these colored parts. The male palpal tibial apophysis (Figs. 28–29) is relatively massive and is subdivided into two closely apposed parts, the ventral one of which terminates in two short processes. The palpal patella (Fig. 28) has a short blunt ventral terminal spine. The epigynum (Fig. 31) is



EXTERNAL ANATOMY OF SPIDERS

(Figures 28–36)

28. *Clubiona abboti*, right male palpus, ventral view
29. *C. abboti*, right male palpal tibia, retrolateral view
30. *C. abboti*, left cheliceral teeth
31. *C. abboti*, epigynum
32. *Clubiona agrestis*, right male palpus, ventral view
33. *C. agrestis*, right male palpal tibia, dorsal view
34. *C. agrestis*, left male cheliceral teeth
35. *C. agrestis*, epigynum
36. *C. agrestis*, left female cheliceral teeth

acutely notched in the middle of the posterior border. In front of the median notch is a pair of openings irregular in shape and separated by a septum. In front of these openings is a prominent transversely rugulose area. The PME are much farther from each other than the PME are from the PLE. The promargin of the fang groove (Fig. 30) has five teeth, the second being the largest. The retromargin of the fang groove has four teeth; the first two are of moderate size and the second two are small.

Clubiona agrestis Emerton

(Figures 32–36, p. 64)

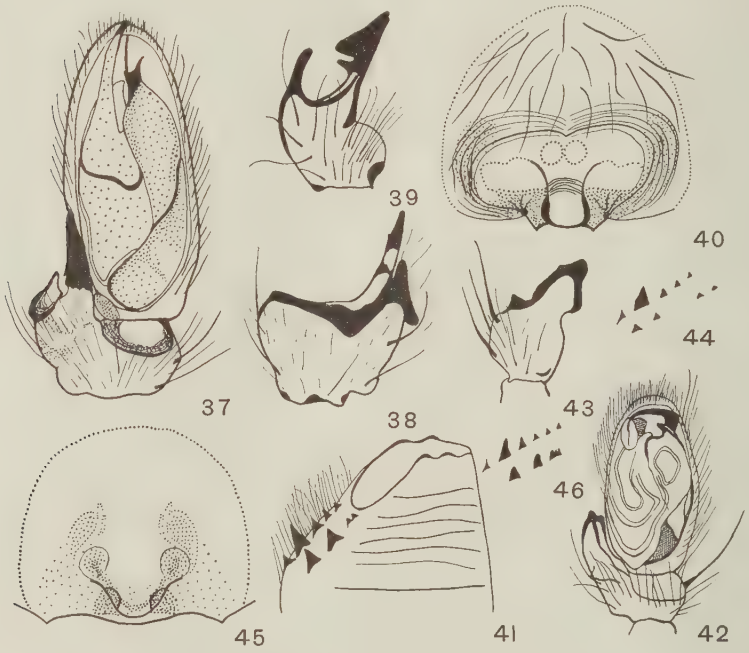
This species was described from "one mature male and one just moulted" taken at Holliston, Mass., in June, 1924. A female also appears in the collection, but it has never been described. Here, for the first time, a figure of the epigynum is provided (Fig. 35). I have one mature individual of each sex from Conway; they were collected from bushes in a roadside marsh. The single mature female is about 7.2 mm. long, the male about 4.4 mm. long. The female is well marked, as follows: The legs are a pale amber. The robust chelicerae are a rich reddish brown. The ground color of the cephalothorax is a light brown, darker on the head region and much streaked with dark brown. Dorsally the abdomen is a reddish brown flecked with yellowish spots. Ventrally it is a lighter brown, with four rows of yellowish dots extending from the genital furrow to near the spinnerets. The male is lighter in color and lacks the more distinctive markings of the female. The male palpal tibial apophysis (Figs. 32–33) is a very characteristic pair of hooklike processes, the ventral one rather evenly curved, the dorsal one bent at a right angle. The epigynum (Fig. 35) is somewhat scutiform in outline and is gently notched in the middle of its posterior border. Its two openings near the posterior border lie about three diameters apart. Lateral and anterior to each of these openings is an irregular groove, indicated by the dotted areas in Figure 35. In the female the PME are about 1.3 as far apart as the distance between the PME and the PLE. In the male the PME are about 1.6 as far apart as the distance between the PME and the PLE. The promargin of the fang groove (Fig. 36) in the female has six teeth; the retromargin, three. In the male (Fig. 34) the promargin has four teeth and the retromargin three.

Clubiona canadensis Emerton

(Figures 37–41, p. 66)

Clubiona canadensis is a common species in the Northern Peninsula and the northern part of the Southern Peninsula, but it has not been collected in the southern part of the state. It has been taken most commonly by beating or shaking deciduous trees and bushes, and sometimes by sifting the fallen leaves. In the vicinity

of the University Biological Station near Douglas Lake it has been collected quite frequently in the rolls of white birch bark, where it seems to like to build its nests. The size is highly variable and in females ranges from about 7 mm. to 11.5 mm. Males are about 7.4 mm. long and are less variable in size than the females. In



EXTERNAL ANATOMY OF SPIDERS

(Figures 37–46)

37. *Clubiona canadensis*, right male palpus, ventral view
38. *C. canadensis*, right male palpal tibia, dorsal view
39. *C. canadensis*, right male palpal tibia, retrolateral view
40. *C. canadensis*, epigynum
41. *C. canadensis*, left female chelicera and teeth
42. *Clubiona moesta*, right male palpus, ventral view
43. *C. moesta*, right male palpal tibia, retrolateral view
44. *C. moesta*, left male cheliceral teeth
45. *C. moesta*, epigynum
46. *C. moesta*, left female cheliceral teeth

well-marked females the robust chelicerae are a rich mahogany brown. The cephalothorax and legs are a light amber color, with the head a little darker. The abdomen has a reddish brown, median basal dorsal lanceolate stripe. The remainder of the abdomen is dorsally and laterally a light reddish brown closely mottled with yellowish spots. Usually there is a series of dorsal recurved narrow bars behind the middle. Ventrally the color of the abdomen is somewhat lighter, and there are three longitudinal stripes marked out by rows of marginal yellowish dots. The central stripe is lighter than the two lateral stripes. The color of the males is much like that of the females, but it is lighter and less distinctive. The male palpal tibial apophysis (Figs. 37–39) is divided into two processes; the ventral one is a long pointed spur with a characteristic notch near its base; the dorsal process is a short and simple spur. The two processes are connected by a semicircular rim. The epigynum (Fig. 40) has a central septum somewhat swollen at the posterior end, but often not visible until the whole organ is turned outward. On either side of the swollen end of the septum there is an irregular, wrinkled, chitinized area. On either side of the constricted central portion of the septum there is a whitish more lightly chitinized area and at the sides and in front of these a transversely wrinkled area. In females the PME are farther from one another than they are from the PLE in a ratio of 16 : 11 and in males in a ratio of 13 : 10. In females the promargin of the fang groove usually has five teeth, of which the second is the largest; the last three are frequently quite small. The retromargin of the fang groove (Fig. 41) generally has four teeth, of which the last two are small and close together. Frequently one of the small ones is lacking. In males the teeth are similar to those in the females, but they appear to be more variable.

Clubiona mixta Emerton

(Figures 68–69A, p. 75)

There is some doubt concerning the validity of this species. Petrunkevitch regards it as a synonym of *Clubiona obesa*, and Emerton suggested that it might be. Miss Bryant seems inclined to regard it as distinct, and for the present I consider it best to do so. Only males are known. I have four mature individuals, all from the Southern Peninsula. Like most other *Clubionae* it is found on bushes

and trees. The size ranges from about 5.2 mm. to 7.3 mm. The chelicerae are considerably produced, and the basal segments are about three fourths as long as the cephalothorax. They are also considerably excavated medially near the distal end, and there is a sharp distal ridge on the prolateral surface. They are colored a dark brown. The legs and cephalothorax are a light amber. The abdomen in well-marked individuals is lighter colored near the base dorsally, but is reddish brown elsewhere except for a broad light stripe along the midventral region. The palpal tibial apophysis (Figs. 68–69) is a stout retrolateral process nearly as long as the body of the tibia and deeply notched on the side nearest the palpus at the distal end. The PME are farther from one another than from the PLE in the ratio 14 : 11. The promargin of the fang groove has five teeth; the second is the largest. The retromargin of the fang groove has four teeth, with the second one the largest (Fig. 69A).

Clubiona moesta Banks

Clubiona pusilla Emerton, 1889.
C. emertoni Petrunkevitch (*C. pusilla* preoccupied by Nicolet in 1849), 1911.
C. orinoma Chamberlin, 1919.

(Figures 42–46, p. 66) .

While working over my Michigan Clubionidae in the Museum of Comparative Zoölogy, Harvard University, during the summer of 1937, I found that *Clubiona orinoma* Chamberlin is a synonym for *C. moesta* Banks. A male with a *C. orinoma* female from Utah seemed very similar to *C. pusilla* Emerton, but there the matter rested until December, 1937, when Miss E. B. Bryant informed me by letter that Dr. Gertsch of the American Museum had recently called her attention to the synonymy as given above. Upon further examination of material from Massachusetts Miss Bryant has concurred in the conclusions given here. The infrequency of this species in my collections indicates that it is not very common in Michigan; I have several specimens of both sexes from the Southern Peninsula and none from the Northern Peninsula. Adult females measure about 5.6 mm. in length, whereas adult males are about 5 mm. long. Females are somewhat more distinctly colored and marked than males. The chelicerae are a reddish brown, the legs are yellowish and the cephalothorax a light amber, somewhat darker on the head region. The abdomen has a faintly outlined reddish brown median basal

dorsal lanceolate stripe, with the remainder of the dorsal and dorsolateral sides finely mottled with yellowish spots and with spots and stripes of light reddish brown. As in several other species, there is a series of indistinct, light-colored, recurved bars across the posterior half of the dorsum. The palpal tibial apophysis (Figs. 42–43) is a simple stout spur somewhat spatulate toward the tarsus. It rather closely resembles the tibial apophysis of *C. obtusa*. The epigynum (Fig. 45) has a broad blunt lobe in the middle of the posterior border, with a small more sharply pointed lobe at each side near the lateral margin of the epigynum. Slightly in front of the middle lobe is an opening on each side, directed laterally and a little more than a diameter apart. The PME are farther from each other than from the PLE in the ratio 11 : 8. In the female the promargin of the fang groove (Fig. 46) has six teeth and the retromargin five, but the last three could be considered a tridentate single tooth. In the male the promargin has five teeth (Fig. 44) and the retromargin four.

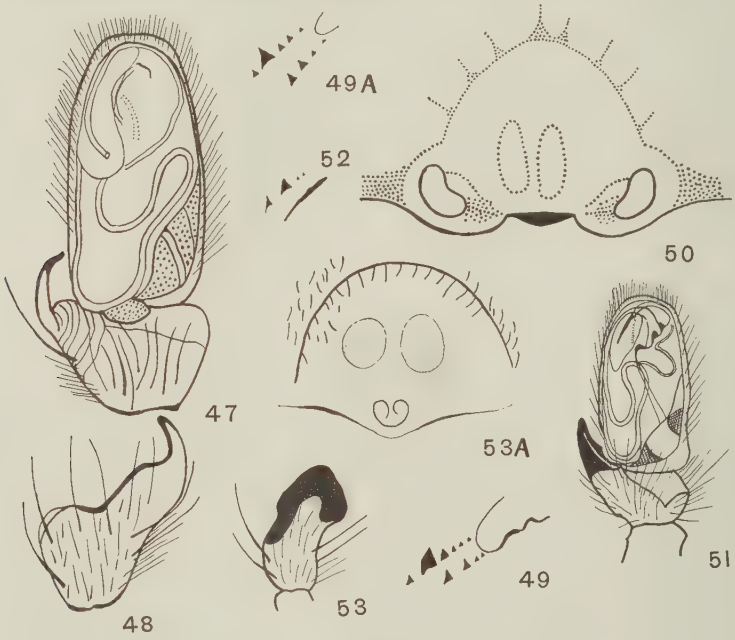
Clubiona obesa Hentz

Clubiona crassipalpis Keyserling, 1887.
C. crassipalpis Emerton, 1889.

(Figures 47–50, p. 70)

This seems to be a common species in the Southern Peninsula, but I have not yet collected it in the Northern Peninsula. Mature females are about 9 mm. long and mature males about 7.5 mm. long. Considerable variation in size has been noted. As I have pointed out elsewhere, this species may have dimorphic males, and hence *Clubiona mixta* may belong here. The robust chelicerae are a reddish brown. The legs are a yellowish color. The cephalothorax is a light amber, darker on the head. The dorsum on the abdomen has a faint median basal lanceolate stripe (not visible in some individuals). Four light-colored muscle impressions usually show quite clearly. Behind these there is a series of light recurved bars, the first few of which have enlarged light-colored terminations. Among these markings and elsewhere the dorsal and lateral regions have many yellowish and reddish brown dots and irregular stripes; the latter occur especially along the sides of the body. In well-marked individuals there is ventrally a broad central stripe, free of dots, tapering toward the base of the spinnerets. The broad stripe is margined with rows of yellowish dots, and along the center are two rows of smaller yellow-

ish dots. The palpal tibial apophysis (Figs. 47–48) is a single stout hook-shaped process which in several ways resembles that of *C. mixta*. The epigynum (Fig. 50) typically has a small posterior median lobe. On each side of this is a more prominent rounded lobe. A little in front and to the side of each lateral lobe there is a prominent oval opening. Slightly before the median lobe and near the middle of the epigynum is a pair of large elongate-oval bodies (receptacles). The



EXTERNAL ANATOMY OF SPIDERS

(Figures 47–53A)

47. *Clubiona obesa*, right male palpus, ventral view
48. *C. obesa*, right male palpal tibia, dorsal view
49. *C. obesa*, left female cheliceral teeth
49A. *C. obesa*, left male cheliceral teeth
50. *C. obesa*, epigynum
51. *Clubiona obtusa*, right male palpus, ventral view
52. *C. obtusa*, left male cheliceral teeth
53. *C. obtusa*, right male palpal tibia, retrolateral view
53A. *C. obtusa*, epigynum

PME are farther from each other than from the PLE in a ratio of 14 : 11. In females (Fig. 49) the promargin of the fang groove usually has six teeth and the retromargin four. In males (Fig. 49A) the promargin of the fang groove usually has five teeth and the retromargin four.

Clubiona obtusa Emerton

(Figures 51–53A, p. 70)

This species was described from Banff, Canada. Four males from Wilderness Park in Emmet County are the only representatives collected in Michigan. These came from grass and bushes along the beach. They average about four mm. long. The chelicerae are a light reddish brown. The legs are yellowish and the cephalothorax a light amber. The dorsum of the abdomen is a light reddish brown in well-marked individuals, with many small yellowish spots but without anything very distinctive in the markings. All the underparts are a very light yellowish color. The tibial apophysis (Figs. 51, 53) is a single very blunt spatulate process. This species must be closely related to *Clubiona moesta*, with whose tibial apophysis there is a close resemblance. The PME are farther from each other than from the PLE in a ratio of 9 : 6. The promargin of the fang groove (Fig. 52) has four teeth, the second two being minute; the retromargin has no teeth, but, usually, a low ridge in their stead.

No females are included in my collections, and therefore I am not able to furnish a description of this sex. Miss E. B. Bryant has, however, kindly drawn a figure of the epigynum, which is reproduced in Figure 53A.

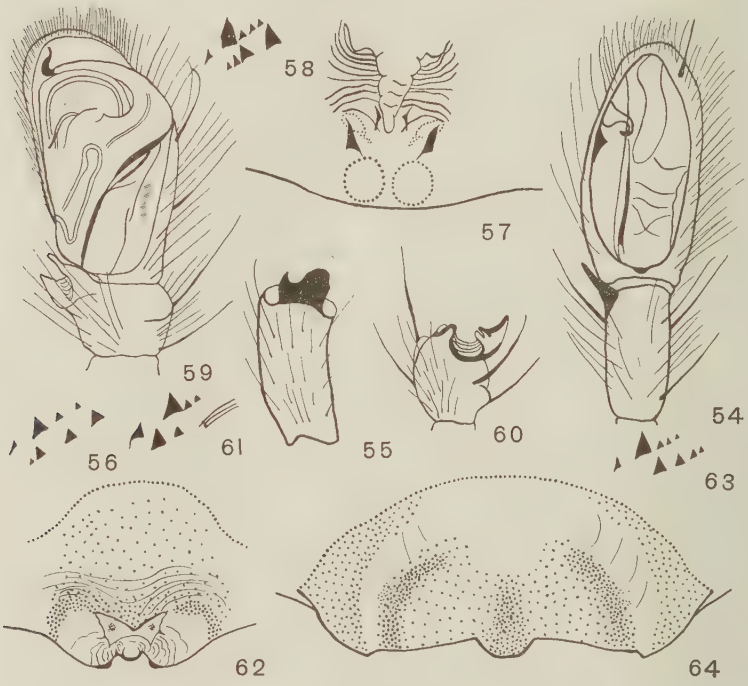
Clubiona pallens Hentz

Clubiona excepta L. Koch, 1866.
C. excepta Emerton, 1889.

(Figures 54–58, p. 72)

This species seems to be quite common in both the Northern and Southern peninsulas. Adult females are about 7 mm. long and adult males about 6.5 mm. long. It is the most distinctively marked species in the region, and the sexes are essentially alike in their markings. The legs are yellowish. The chelicerae are a light reddish brown. The dorsum of the abdomen is typically provided with three series of black markings on the yellow background. There is usually a basal median stripe (frequently lacking in males) behind which

there are seven or eight recurved bars, each more or less broken in the middle. At each side of this central series occurs a series of five or six oblique black bars. The underparts are a light yellow, sometimes with two small black or gray spots just in front of the



EXTERNAL ANATOMY OF SPIDERS

(Figures 54–64)

54. *Clubiona pallens*, right male palpus, ventral view
55. *C. pallens*, right male palpal tibia, retrolateral view
56. *C. pallens*, left male cheliceral teeth
57. *C. pallens*, epigynum
58. *C. pallens*, left female cheliceral teeth
59. *Clubiona riparia*, right male palpus, ventral view
60. *C. riparia*, right male palpal tibia, retrolateral view
61. *C. riparia*, left male cheliceral teeth
62. *C. riparia*, epigynum
63. *C. riparia*, left female cheliceral teeth
64 *Clubiona tibialis*, epigynum

base of the spinnerets. The tibial apophysis (Figs. 54–55) is a short, retrolateral, bladelike extension with two processes along the distal margin. The dorsal process is a short sharp hook, whereas the ventral one is broad and blunt. The epigynum (Fig. 57) is very unlike any other known in our fauna. There is a long and somewhat rugulose free tongue overlying a transversely rugulose area. In the female the PME are farther from one another than from the PLE in the ratio 11.5 : 9; in the male the ratio is 9 : 7. In females the promargin of the fang groove (Fig. 58) is armed with five teeth, of which the second is relatively very large; the retromargin is armed with four teeth, of which the last two are large. In the male each margin usually has four teeth (Fig. 56).

Clubiona pygmaea Banks

Clubiona lenta Banks, 1892.

(Figures 70–71, p. 75)

Only one mature female of this species has been collected in Michigan; it was taken at Quincy in the extreme southern part of the state, when low bushes and tall marsh grass were being swept. This specimen is only 3.9 mm. long. The general color is light yellowish, with amber cephalothorax and chelicerae. The dorsum of the abdomen shows flecks of brown with indistinct light, recurved bars on the posterior half. The underparts are all very light colored. It seems probable that the color of this animal has faded considerably in the alcohol since it was collected. The epigynum (Fig. 70) is quite distinctive. Just anterior to the single median lobe there is a single somewhat pyriform opening within which appear two small, nearly circular, secondary apertures. The PME are farther from each other than from the PLE in the ratio 2 : 1. The promargin of the fang groove (Fig. 71) has three teeth, of which the middle one is the largest; the retromargin has two teeth.

Clubiona riparia L. Koch

Clubiona ornata Emerton, 1889.
C. americana Banks, 1892.
C. riparia Banks, 1895.
C. ornata Simon, 1903.

(Figures 59–63, p. 72)

This is one of our most common clubionids. It has been collected in the Northern Peninsula and in many localities throughout the

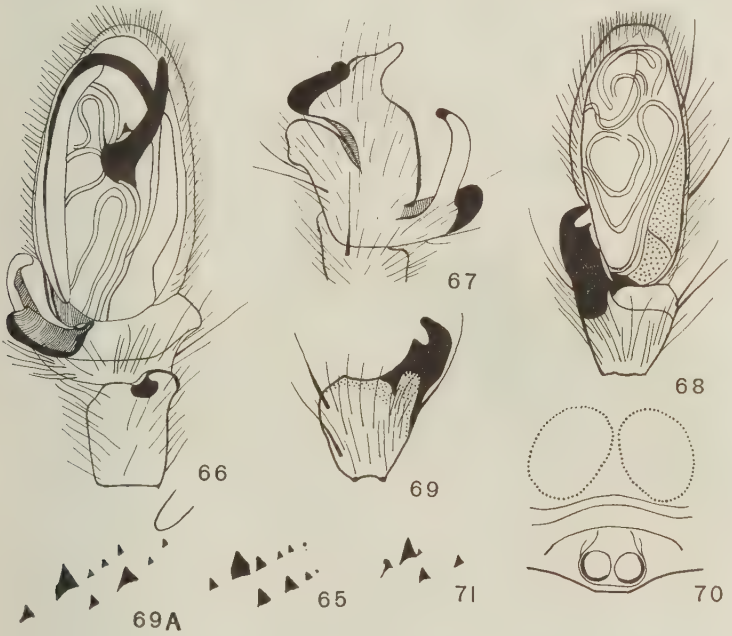
Southern Peninsula. Adult females are about 6.5 mm. long and adult males about 5.5 mm. long. The nest-building habits of these spiders are especially interesting. The females construct long three-sided chambers by folding broad-leaved grasses, as shown by Comstock (p. 568, fig. 643). Within these chambers females and their egg sacs and, later, the spiderlings may be found during the nesting season. This is a well-marked species as compared with the majority of the members of the genus. The chelicerae are reddish brown, and the legs are a light amber. The cephalothorax is darker amber. The dorsum of the abdomen is a reddish brown of variable shade in different animals. Extending nearly throughout the middle of the abdomen is a lighter stripe; along the center of this is a deeply colored stripe more or less dentate on both sides. The lateral sides of the abdomen are a lighter brown. Along the middle of the ventral area from the genital furrow to the base of the spinnerets is a light stripe tapering posteriorly, and on each side of this stripe is a reddish brown stripe with an outer margin of light dots. The tibial apophysis (Figs. 59–60) resembles that of *Clubiona canadensis*, but it is much smaller, and the remainder of the palpus is quite different. The epigynum (Fig. 62) has three lobes along the posterior border, a small median lobe and two larger lateral lobes, which are very light colored, somewhat rugulose, and lightly chitinized. Just in front of the median lobe is a deep depression over which extends a short tongue that sometimes quite divides the depression. In front of the tongue is a transversely rugulose area. In the female the PME are farther from one another than from the PLE in the ratio 11 : 7; in the male the ratio is 10 : 6.5. In females the promargin of the fang groove (Fig. 63) has five teeth and the retromargin four. In many males the promargin of the fang groove (Fig. 61) has four teeth, the retromargin three; often there are some striations beyond the teeth. On one male examined the promargin had five teeth and the retromargin three. My experience in counting teeth on the margins of the fang groove has convinced me that great caution must be used in stressing this feature as a character of taxonomic importance.

Clubiona tibialis Emerton

(Figures 64–67, pp. 72, 75)

A single female of this species has been collected in Michigan (Calhoun County), but Miss Bryant loaned me a male from Mary-

land from which to draw a figure of the male palpus. The single female was taken among the tall grass of a marsh. It is 8.33 mm. long, and the cephalothorax and chelicerae are a dark reddish brown. The posterior two thirds of the cephalothorax are an amber color, but this darkens to a reddish brown in the region of the eyes. Four light-colored muscle impressions show clearly on the dorsum of the abdomen. Otherwise the dorsum is a mottled area of yellowish and



EXTERNAL ANATOMY OF SPIDERS

(Figures 65–71)

65. *Clubiona tibialis*, left female cheliceral teeth
66. *C. tibialis*, right male palpus, ventral view
67. *C. tibialis*, right male palpal tibia, dorsal view
68. *Clubiona mixta*, right male palpus, ventral view
69. *C. mixta*, right male palpal tibia, dorsal view
69A. *C. mixta*, left male cheliceral teeth
70. *Clubiona pygmaea*, epigynum
71. *C. pygmaea*, left female cheliceral teeth

reddish brown spots and irregular stripes. These markings are lighter laterally, and the venter is yellowish. The tibial apophysis (Figs. 66–67) is large and overlaps the tarsus extensively. It is subdivided into three portions; the most ventral process is a slender hook, the middle process is the longest and broadest, and the dorsal process is short and blunt. The epigynum (Fig. 64) is nearly twice as wide as long, a condition distinctive among Michigan *Clubionae*. There is a small central lobe with a massive lobe on each side of it. The body of the epigynum has four low ridges and no external openings; this, also, is an unusual feature. The PME are farther from one another than from the PLE in the ratio 19 : 12. In the female the promargin of the fang groove (Fig. 65) has six teeth and the retromargin four. On both margins the last tooth is minute. In the male loaned by Miss Bryant the promargin has four teeth and the retromargin three.

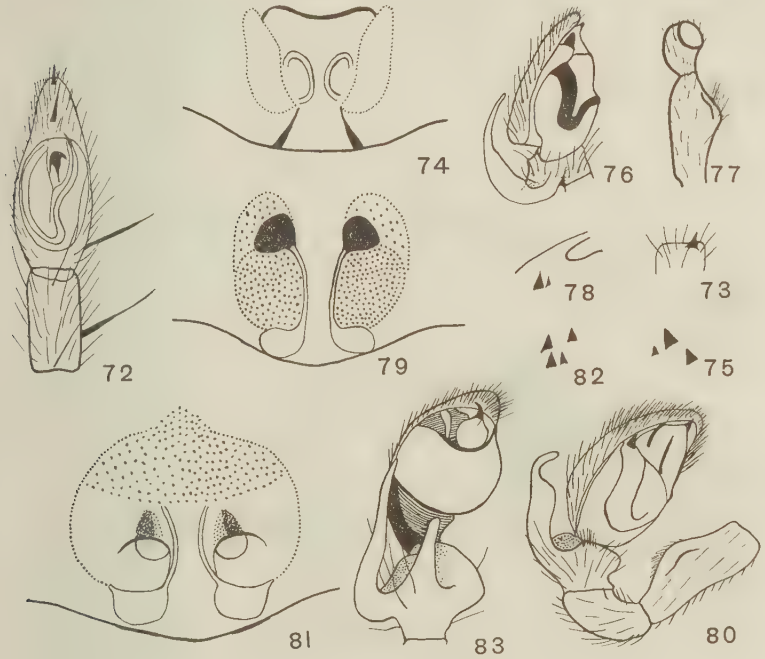
Genus MICARIA Westring, 1851

Micaria montana Emerton

(Figures 72–75, p. 77)

Since only five specimens of this species appear in my collection from Michigan I regard it as not common in the state. All these specimens were collected in Calhoun County in the spring and fall of the year by sifting litter from fields, woods, and roadsides. The females in my collection average about 3.9 mm. in length and the single male is 3.3 mm. long. In the female all femora are dark, the first two pairs being almost black. All segments distal to the femora of the first two pairs of legs are yellowish; in the last two pairs of legs these distal segments are darker. The medial and retrolateral surfaces of the chelicerae are yellowish; elsewhere they are dark brown. The sternum and cephalothorax are dark brown; the latter has many spots and streaks of black. The abdomen is a shiny black covered with iridescent scales. Just a little in front of the middle of the abdomen there is a narrow band of white scales which passes down the lateral sides but does not cross the venter. Near the base of the abdomen is another white band, usually broken into a series of spots. Behind the middle band is a median series of white spots extending to the postabdomen, which is yellowish. The coloration of the male is similar to that of the female, but the chelicerae and legs are somewhat lighter and the white bands and spots are lacking

in my single male specimen. The tibial apophysis (Figs. 72–73) is a short simple dorsal spur. The epigynum (Fig. 74) is a somewhat concave plate with two openings directed laterally just anterior to the genital furrow and with a chitinous margin at the anterior border.



EXTERNAL ANATOMY OF SPIDERS

(Figures 72–83)

72. *Micaria montana*, right male palpus, ventral view
73. *M. montana*, right male palpal tibia, dorsal view
74. *M. montana*, epigynum.
75. *M. montana*, left male cheliceral teeth
76. *Phrurolithus alarius*, right male palpus, a somewhat retrolateral view
77. *P. alarius*, right male palpal femur and patella, retrolateral view
78. *P. alarius*, left female cheliceral teeth
79. *P. alarius*, epigynum
80. *Phrurolithus borealis*, right male palpus, a somewhat retrolateral view
81. *P. borealis*, epigynum
82. *P. borealis*, left female cheliceral teeth
83. *Phrurolithus formidabilis*, right male palpus, a somewhat retrolateral view

The posterior row of eyes is distinctly procurved. In the male the promargin of the fang groove (Fig. 75) has two teeth and the retromargin has but one. The teeth have not been clearly seen in the female.

Genus PHRUROLITHUS C. Koch, 1839

KEY TO THE SPECIES OF *PHRUROLITHUS*

MALES

1. Palpal tibial apophysis a single long process; palpal femora with a low ventral elevation 2
1. Palpal tibial apophysis composed of two elongations; palpal femora with a prominent ventral hooked process ..... *Phrurolithus formidabilis*, p. 80

2. Palpal tibial apophysis a long, gently curved, sickle-shaped process not apically bent toward the tarsus ..... *P. alarius*, p. 78
2. Palpal tibial apophysis a long process with outer border nearly straight until near the tip, where it bends almost at a right angle toward the tarsus ..... *P. borealis*, p. 79

FEMALES

1. Proximal three fourths of anterior tibiae black with the tip light colored; gray central parallel lines on ventral side of abdomen... *P. borealis*, p. 79
1. Proximal three fourths of anterior tibiae not black; ventral side of abdomen without any distinct gray parallel lines 2

2. All legs more or less darkly ringed; cephalothorax with a marginal dark line and a broad stripe on each side; seminal receptacles close to posterior border of epigynum and elongated ..... *P. alarius*, p. 78
2. All legs without definite dark rings; cephalothorax unicolorous reddish brown with numerous dark spots and streaks; seminal receptacles remote from posterior border of epigynum and nearly circular *P. formidabilis*, p. 80

Phrurolithus alarius (Hentz)

Herpyllus alarius Hentz, 1847.
Phrurolithus alarius Emerton, 1889?
P. palustris Banks, 1892.
P. alarius Emerton, 1911.

(Figures 76–79, p. 77)

This is a common species in the Southern Peninsula, where I have collected it many times from forest litter and trash. So far as I know, it has not been reported from the Northern Peninsula. Adult females are about 2.6 mm. long and adult males a little more than 2 mm. long. The coloration is about the same in the two sexes.

The legs are yellowish with black on the front surface. The cephalothorax is yellowish with a narrow black margin and two broad stripes much spotted and streaked with black reaching from the eyes and meeting posteriorly, thus leaving the middorsal region free of color. The thoracic groove is distinct. "The abdomen is marked [dorsally] by short lines and chevrons more or less broken into spots" (Emerton, 1911); the markings are often somewhat less distinct in the males. There are usually two gray spots on the venter about halfway from the genital groove to the base of the spinnerets. The male palpal tibial apophysis (Fig. 76) is a single long slender evenly curved sickle-shaped process. Each palpal femur (Fig. 77) has a low hump on the ventral surface. The epigynum (Fig. 79) has its openings a little more than a diameter apart and three diameters from the genital furrow at the anterior end of small ducts. The posterior row of eyes is slightly recurved, and the eyes are close together. There is a little uncertainty in regard to the teeth of the fang groove (Fig. 78), but apparently the promargin has no teeth and the retromargin has two.

Phrurolithus borealis Emerton

(Figures 80–82, p. 77)

This species was originally included with *Phrurolithus alarius*, but was separated from it by Emerton in 1911. It is fairly common throughout the state, and frequents the same types of habitat as the preceding species. Adult females are about 2.8 mm. long; adult males, about 2.5 mm. long. In a general way the coloration is similar to that of *P. alarius* but much darker. There are several specific differences, however. The anterior patellae are black at the distal ends and on the ventral, prolateral, and retrolateral surfaces. On the dorsal surface of the anterior patellae there is an elongated light spot within the center of which there is a narrow black stripe. The anterior tibiae are black except at the distal ends, which are white. The black portions of the anterior tibiae are covered by a coating of hair that is strongly developed on the ventral surface. The second legs tend to have markings which are similar to those of the anterior legs, but not nearly so well developed. The last two pairs of legs are almost devoid of color. The cephalothorax is marked much as in *P. alarius* except that the broad stripes are wider. The abdomen is generally black or dark brown with iridescent scales. On the

posterior two thirds of the dorsum of the abdomen there is a series of light somewhat oblique bars often meeting in the center. The underparts are generally yellowish, but there is usually a narrow broken black margin to the sternum; in front of the genital furrow a small black spot often occurs, and before the spinnerets is an elongated spot of considerable size. The female is somewhat lighter in color than the male. The tibial apophysis (Fig. 80) is a single stout spur bent rather sharply toward the tarsus near the tip. The femur (Fig. 80) of the palpus has a low elevation near the middle of the ventral surface. The epigynum (Fig. 81) has its openings about two diameters from the genital groove and not at the anterior ends of small ducts. The posterior eyes are slightly procurved and the PME are elongate-oval and obliquely placed. Each margin of the fang groove (Fig. 82) has two teeth.

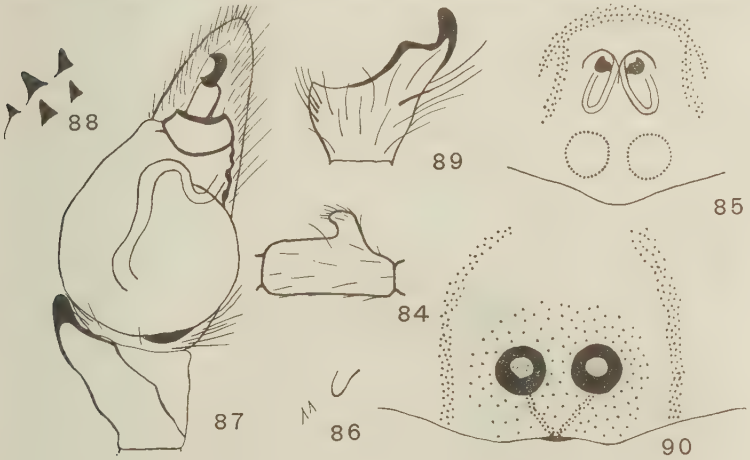
Phrurolithus formidabilis (Chamberlin and Gertsch)

Phruronellus formidabilis Chamberlin and Gertsch, 1930.

(Figures 83–86, pp. 77, 81)

Gertsch has recently shown (1936) adequate reasons for considering *Phruronellus* congeneric with *Phrurolithus*. I have found this species fairly common in trash and forest litter in the southern part of the state, and I have one record from the Northern Peninsula. Adult females are about 2.35 mm. long and males are about 2.1 mm. long. Therefore this is the smallest of the three well-known species from Michigan. In both sexes the cephalothorax is a light brown much streaked with black. This characteristic offers a sharp contrast with the two preceding species. In the female the dorsum of the abdomen is generally dark brown with a conspicuous light band (chevron-like) slightly in front of the middle. Behind this band there is a series of smaller faint but similar bands all more or less like chevrons. The spinnerets and postabdomen are white, and dorsal to these is a small white spot. The underparts are generally yellowish. At the base of the spinnerets there is a narrow dark band, and still farther anterior, near the middle of the area between the genital groove and the spinnerets, is an irregular gray spot of considerable size. The legs are generally yellowish, but the femora of the first two pairs of legs have considerable color on the prolateral and retrolateral surfaces. The male has a similar coloration though

darker than the female. The single transverse band near the middle of the abdomen is conspicuous, whereas the fainter posterior ones are almost wholly lacking. The ventral area is nearly all dark gray. The tibial apophysis (Fig. 83) is subdivided into two slender processes, the dorsal of which is nearly as long as the tarsus. The palpal femur (Fig. 84) has a conspicuous ventral hook instead of the low elevation



EXTERNAL ANATOMY OF SPIDERS

(Figures 84–90)

84. *Phrurolithus formidabilis*, right male palpal femur, retrolateral view
85. *P. formidabilis*, epigynum
86. *P. formidabilis*, left female cheliceral teeth
87. *Trachelas tranquillus*, right male palpus, ventral view
88. *T. tranquillus*, left male cheliceral teeth
89. *T. tranquillus*, right male palpal tibia, dorsal view
90. *T. tranquillus*, epigynum

characteristic of *Phrurolithus alarius* and *P. borealis*. The epigynum (Fig. 85) is very unlike that of either of these two species. The openings are smaller, closer together, and farther from the genital furrow, and the receptacles are circular in outline instead of oblong, as in *P. alarius* and *P. borealis*. The posterior eyes appear to be very slightly procurved in the male but straight in the female. Although the margins of the fang groove (Fig. 86) are not easily seen, it is probable that the promargin has two teeth and the retromargin none.

Genus TRACHELAS L. Koch, 1866

Trachelas tranquillus (Hentz)

Clubiona tranquilla Hentz, 1847.
Agelena plumbea Hentz, 1847.
Trachelas ruber Keyserling, 1887.
T. ruber Emerton, 1889.
T. tranquillus Banks, 1892.

(Figures 87–90, p. 81)

This species seems to be common throughout the Southern Peninsula, but it has not been reported from the Northern Peninsula. Adult females are about 8.7 mm. long and adult males about 5.5 mm. long, but a great variation in size has been noted. These animals may be sifted from litter along roadsides, in gardens, dry forests, etc. The chelicerae, maxillary lobes, sternum, and cephalothorax are a bright mahogany reddish brown. The chelicerae, sternum, and cephalothorax are all thickly covered by small shallow pits. The first two pairs of legs are much longer and more robust than the last two pairs. The legs are a light amber color, with the first pair considerably darker than the others. The abdomen is a dull yellowish with a faint dark basal dorsal narrow stripe. There are distinctive cuspules on the ventral surface of the tibiae, metatarsi, and tarsi of the first two pairs of legs. The male palpal tibial apophysis (Figs. 87, 89) is a single stout spur of moderate length curved near the tip toward the tarsus and dorsally. The epigynum (Fig. 90) is a chitinous plate within which are two conspicuous circular openings slightly more than half a diameter apart and about a diameter from the genital furrow. The posterior eyes are strongly recurved. The promargin of the fang groove (Fig. 88) has three teeth, the retromargin has two.

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SPECIFICITY WITHIN THE AMPHIBIA OF PITUITARY GONADOTROPIC FACTORS DERIVED FROM AMPHIBIA

CHARLES W. CREASER AND MARGARET SHCOLNEK

INTRODUCTION

SPECIES specificity of the pituitary gonadotropic factors was first indicated by Houssay (1929). Many writers have since published data bearing upon the subject. Creaser and Gorbman (1935, 1936, 1938) definitely established the specificity of certain pituitary gonadotropic factors. These factors, derived from fish and mammals and injected into amphibia, failed to produce ovulation in frogs known to be capable of ovulation. They furnished evidence that this specificity is not always absolute, but may be a matter of degree in that there is a varying response to gonadotropic factors, depending upon the phylogenetic relationship between the donor and the recipient of the pituitary preparation. Other investigators (see bibliography of Creaser and Gorbman, 1939), working with mammalian glands in fishes, birds, and reptiles, have further established the refractoriness of members of one vertebrate class to the gonadotropic factors of other vertebrate classes. It is the purpose of the present study to describe the specificity which we have found within the amphibia of pituitary gonadotropic factors derived from an amphibian.

REASONS FOR CHOICE OF *NECTURUS* AND *RANA PIPIENS* AS TEST ANIMALS

Investigators (Barth, 1933; Rugh, 1934, 1935; Creaser and Gorbman, 1935, 1936, 1939) have found that *Rana pipiens* is highly refractory to extraspecific pituitary gonadotropic preparations. No pituitary preparation derived from an animal which is more specialized phylogenetically than the genus *Rana* has been found to stimulate extraseasonal ovulation in *R. pipiens*. Wills, Riley, and Stubbs (1933b) report one instance of ovulation induced in *R. pipiens* with

glands from *Lepisosteus*. Later experiments on fishes (Creaser and Gorbman, 1936) have failed, however, to reproduce these results, although as yet *Lepisosteus* has not been retested. Aside from this one instance ovulation out of season has been brought about in *R. pipiens* only by homoplastic implants or by implants of glands from certain other members of the genus *Rana* (see Table II).[1] In order to understand more fully the significance of these data it is necessary to determine whether the glands of a more phylogenetically primitive amphibian, such as *Necturus*, could produce a gonadotropic substance capable of ovulating the frog *R. pipiens*. *Necturus maculosus* (Rafinesque) was selected because specimens are large and plentiful. The pituitary glands are big and easily removed. Zoölogists (Noble, 1931; Stejneger and Barbour, 1933) are generally agreed that *Necturus* is an amphibian which became differentiated from the ancestral line at an earlier point in the phylogenetic history of the class than did the frog.

METHODS EMPLOYED

The pituitary glands were taken from live animals by cutting through the jawbones and then removing the top of the head along a line joining the most anterior gills. The pituitary gland of *Necturus* is easily seen through the parasphenoid bone when the lining membrane is scraped away from the roof of the mouth. It appears as a round pinkish body about twice the size of a pinhead. A small square of the cartilaginous parasphenoid bone was cut loose around the gland. This was lifted up and the gland was exposed lying attached to the ventral surface of the infundibulum. Sometimes the gland was torn loose from its attachment to the brain in the process of lifting away the bone. In this case it was found in the small depression, the sella turcica, of the floor of the brain case, where it rests during life.

The glands were removed with a small sharp blade and immediately transferred to the frog. Two different methods of administering the doses were used, but no apparent difference in results was noted. Some glands were placed in a small dry vial and macerated with a

[1] Since this paper was written (Abstract, *Anat. Rec.*, 70, No. 1, p. 117) Gorbman (unpublished) has ovulated *R. pipiens* with *Bufo marinus*, and Adams and Granger (*Proc. Soc. Exp. Biol. and Med.*, 38 : 552. 1938), with a large number of *Triturus viridescens* implants.

glass rod. Then 0.5 c.c. of tap water was added, after which the mixture was injected into the left dorsal lymph space of the frog with a small hypodermic syringe. Particles of the glands were sometimes lost by this method because they were too large to go through the syringe needle. By another method a small hole was cut in the skin of the frog and the whole gland was inserted on the end of a needle and injected into the left dorsal lymph space. This was easier than macerating the glands and injecting them mixed with water, but movements of the frog's legs near the point of injection occasionally forced the glands out through the opening in the skin. Later this loss was prevented by making the opening in front of the sacral hump and pushing the glands to the caudal part of the lymph space.

Records were kept of individual frogs by making a map of the dorsal view of each frog showing the position and shape of all the spots between the lateral skin folds. No two frogs have spots in the same position or of the same shape and size. Many control specimens were kept in the laboratory under similar environmental conditions. In this experiment the animals were not fed. Little attention was paid to such environmental conditions as light, temperature, or the presence of males. Consideration of these things was not deemed necessary because frogs in the same environment were used twice, once with *Necturus* implants and once with homoplastic implants. Since the only variable factor was the donor of the glands, any difference in results must be attributed to a difference in the glands supplied. This form of check has been described by Creaser and Gorbman (1935, 1936).

RESULTS OF EXPERIMENTS WITH *NECTURUS* AND *RANA PIPIENS*

(Discussion of Table I)

In all the test frogs the glands of *Necturus* failed to cause ovulation. Each frog was found to be capable of laying eggs when stimulated with homoplastic implants. The number of glands from *R. pipiens* required to bring about the liberation of eggs by stripping varied with each individual specimen. An attempt was made to eliminate the factor of the sex of the donor by using equal numbers of glands from both sexes. This procedure was not always possible. The results show, however, only a slight, if any, quantitative difference in the potency of male and female glands (Rugh, 1937). The administration of both *Necturus* and *R. pipiens* glands caused a

TABLE I

TREATMENT OF *RANA PIPIENS* WITH *NECTURUS* GLANDS

Three glands were used in each dose.

Frog	Source of live glands	How administered	Total no. glands	Dates	Results	Remarks
No. 3	Necturus	Macerated in 0.5 c. c. H_2O	6 ♀ and 12 ♂	Nov. 5-23	Unable to obtain eggs by stripping	Expansion of melanophores after injections very slight
	R. pipiens	Macerated in 0.5 c. c. H_2O	4 ♀ and 5 ♂	Dec. 1–7	Ovulation Dec. 8 without stripping	Melanophore expansion marked. Few eggs free in water Dec. 8, rest obtained by stripping
No. 5	Necturus	First two doses macerated in 0.5 c. c. H_2O. Others whole implants	5 ♀ and 7 ♂	Jan. 23-30	No eggs by stripping	
	R. pipiens	Whole implants	9 ♀	Feb. 5–10	Ovulation Feb. 11 by stripping	
No. 6	Necturus	Whole implants	4 ♀ and 8 ♂	Jan. 23-30	No eggs by stripping	
	R. pipiens	Whole implants	6 ♀	Feb. 5 and 8	Eggs by stripping Feb. 9	
No. 7	Necturus	First two doses macerated in 0.5 c. c. H_2O. Others whole implants	6 ♀ and 6 ♂	Jan. 23-30	No eggs by stripping	
	R. pipiens	Whole implants	3 ♀	Feb. 5	Eggs by stripping Feb. 8	

peculiar granular effect in the skin of the frogs, especially around the point of injection. The melanophore expansion was marked after the homoplastic implants, but very slight after the implants of *Necturus* glands. Clasping behavior of male and female was observed among the controls in the laboratory during the course of the experiments, but no ovulation followed. The best indication of the presence of effective gonadotropic factors is the production of eggs, either freely or by stripping.

Doses of *Necturus* glands far in excess of those usually found effective with homoplastic implants were injected into the test frogs without any result. Since the specificity of the gonadotropic factors is a matter of degree and is not always absolute, it is possible, of course, that even larger doses than those used might have resulted in ovulation. The potency of *Necturus* glands is unknown in terms of their effect either upon members of their own species or upon any other animals. In some specimens the glands themselves are twice as large as those of *R. pipiens.* In this experiment one frog received four times as many glands of *Necturus* as of *R. pipiens;* two others, twice as many *Necturus* glands; and a fourth, equal doses of glands from both. It may be found that doses larger than those used can cause ovulation, but the fact that there is such a disparity between the number of homoplastic implants required to produce ovulation and the number of *Necturus* glands tried without results already clearly indicates the existence of a specificity of gonadotropic factors within the class amphibia.

SPECIFICITY OF PITUITARY GONADOTROPIC FACTORS AS SEEN IN OTHER EXPERIMENTS WITH AMPHIBIA

(Discussion of Table II)

Experiments with homoplastic implants of pituitary glands in amphibia have always been successful in inducing ovulation when ovulation was known to be possible. Heteroplastic implants have met with varying degrees of success among the different species of amphibians. Some forms, such as *Triturus viridescens,* can be induced to ovulate with glands from several widely different donors; in others, such as *R. pipiens,* ovulation has been stimulated only by members of the same genus. The forms which respond to the greatest variety of glands are the more primitive forms, as is shown in Table II. Members of the order Urodela have been induced to lay eggs with

TABLE II

CASES OF INDUCED OVULATION IN AMPHIBIA WITH AMPHIBIAN PITUITARY GLANDS

(Compiled from Creaser and Gorbman, 1939)

All the implants were fresh except that for *Bufo arenarum*. The publications of authors cited in the last column may be found in the article by Creaser and Gorbman.

Recipient	Source of preparation	Authority
Bufo americanus	1. R. pipiens plus R. sphenocephala	1. Wills, Riley, and Stubbs
Bufo arenarum	1. B. arenarum* 2. Leptodactyllus ocellatus	1. Houssay and others; Novelli 2. Novelli
Bufo d'Orbignyi	1. B. d'Orbignyi 2. B. arenarum	1. Houssay and others 2. Houssay and others
Bufo fowleri	1. B. fowleri 2. R. catesbiana 3. R. clamitans 4. R. palustris 5. R. pipiens	1–5. Rugh
Bufo marinus	1. B. marinus	1. Houssay and others
Bufo vulgaris	1. B. vulgaris	1. Adams
Desmognathus fuscus	1. R. pipiens 2. R. pipiens plus Gyrinophilus	1. Noble and Evans 2. Noble and Evans
Eurycea bislineata	1. E. bislineata	1. Noble and Richards
Gyrinophilus porphyritius	1. R. pipiens	1. Noble and Richards
Leptodactylus ocellatus	1. B. arenarum	1. Novelli
Pseudobranchus striatus	1. "Pituitary implants" (probably R. pipiens)	1. Noble and Richards
Rana catesbiana	1. R. clamitans 2. R. pipiens	1. Rugh 2. Rugh
Rana clamitans	1. R. clamitans 2. R. catesbiana 3. R. palustris 4. R. pipiens 5. B. fowleri	1–5. Rugh

* Implants and dried powder were used.

TABLE II (*Concluded*)

Recipient	Source of preparation	Authority
Rana pipiens	1. R. pipiens 2. R. catesbiana 3. R. clamitans 4. R. sphenocephala	1. Bardeen, Barth, Creaser and Gorbman, Rugh, Wolf 2–4. Creaser and Gorbman
Rana vulgaris	1. R. vulgaris 2. B. vulgaris	1. Adams 2. Adams
Rhycatron olympicus ...	1. Desmognathus, Eurycea, and R. catesbiana	1. Noble and Richards
Stereochilus marginatum	1. R. pipiens	1. Noble and Richards
Triton cristatus	1. T. cristatus 2. R. pipiens	1. Adams; Noble and Richards 2. Adams
Triturus pyrrhogaster ...	1. T. pyrrhogaster 2. R. catesbiana 3. R. pipiens	1 .Barth 2. Creaser and Gorbman 3. Barth
Triturus viridescens	1. T. viridescens 2. R. pipiens 3. Bufo terrestris	1. Adams, Barth, Morgan, and Sondheim, Noble and Richards 2. Adams, Barth 3. Adams

pituitary preparations from cattle and sheep (Adams, 1930 a–b, 1934) and birds (Stein, 1934), and with extracts from human pregnancy urine (Ogilvie, 1933), and many other preparations. The forms which show the greatest degree of specificity are the more phylogenetically differentiated members of the order Anura. Ovulation has been induced in the genus *Bufo* with glands from the Bufonidae and Ranidae, and also from the genus *Rana*. *Rana clamitans* (Rugh, 1935) and *Rana vulgaris* (Adams, 1931a) respond to implants of glands from the genus *Bufo*, but we have found ovulation in *R. pipiens* only by homoplastic implants or by glands from other closely related species of the genus *Rana* (Creaser and Gorbman, 1939).

From the evidence presented in Table II it seems that, as the amphibia became more highly specialized physiologically, they lost their ability to respond to the pituitary gonadotropic factors of forms which remained phylogenetically more primitive, whereas these

more primitive forms retained the ability to respond to the pituitary gonadotropic factors of the members of those genera which became more highly specialized. Several explanations have been offered for the inaction of a heteroplastic pituitary implant, but all of them still await further supporting evidence. Creaser and Gorbman (1939) conclude that the hormones of the different species may be chemically different. Smith (1932) discusses some unpublished experiments of Detwiler which show that frog tissue grafts in toads disintegrate and suggests that a recipient may have an "antagonism against the hormones of other animals which causes either the destruction of the active principle or prevents the fixation of an active principle by an organ." They agree that the difference in internal environment in which a heteroplastic implant must function may be an influential factor. Red blood cells of *Necturus* are larger and fewer than those of *Rana*, and the general rate of metabolism is slower (Noble, 1931). The aquatic mode of life gives *Necturus* a more constant body temperature than *Rana* maintains in the course of its continual changing from land to water. Each year during the period of hibernation the frog experiences a great change in all its physiological functions. *Necturus* does not hibernate. All these factors combine to make the environment of a *Necturus* pituitary implant in the lymph space of *R. pipiens* different from its natural internal one. Its ability to function in the lymph space has been shown to be very different from the ability of a *R. pipiens* gland to function in the same lymph space. The reciprocal test with *R. pipiens* as donor and *Necturus* as recipient has not been made, but Noble and Richards (1932) were successful in ovulating *Pseudobranchus striatus*, which is another gilled amphibian rather closely related to *Necturus*, with glands from an amphibian, probably *R. pipiens*. This species has also ovulated the *Urodela: Desmognathus*, *Gyrinophilus*, *Stereochilus*, *Triton*, and *Triturus* (see Table II), but no successful reciprocal tests are known. The one experiment described in this paper in which an attempt was made to ovulate *R. pipiens* with pituitary glands from a more primitive amphibian proved unsuccessful. Again it appears to be something other than a difference in internal environment which inhibits the action of foreign pituitary gonadotropic factors in certain amphibia. It seems that the *Anura*, in the course of their differentiation, developed pituitary gonadotropic factors or response mechanisms which are different from those of the *Urodela*, and though they still

are able to ovulate the more primitive *Urodela*, the gonadotropic factors of the *Urodela* tested are no longer effective in the *Anura*. No acceptable explanation of the nature of this specificity of pituitary gonadotropic factors has been proposed. We have seen it demonstrated in *R. pipiens* and *Necturus*, and previous workers have shown its existence among certain other amphibia.

Recently Adams and Tukey (1937) have indicated that the reverse specificity exists between mammal and amphibian. They injected the anterior pituitaries of *R. pipiens* into immature female mice, but could not induce precocious sexual maturity such as was obtained with homoplastic pituitary treatment.

CONCLUSIONS

1. Specificity of the pituitary gonadotropic factors derived from amphibians exists within the class Amphibia.

2. It has so far been impossible to ovulate *R. pipiens* with pituitary preparations from a more primitive amphibian group.

3. The degree of specificity shown in the response of one amphibian to the pituitary gonadotropic factors of amphibians of other genera increases with the degree of phylogenetic specialization of the recipient of the pituitary preparation. Physiological differentiation of an amphibian is accompanied by changes, probably biochemical, in the pituitary gonadotropic factors or in response mechanisms which render it unable to respond to the secretions of less specialized forms though still able to induce ovulation in those same forms.

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A COMPARISON OF THE OLFACTORY AND THE ACCESSORY OLFACTORY BULBS IN CERTAIN REPRESENTATIVE VERTEBRATES

ELIZABETH CAROLINE CROSBY AND TRYPHENA HUMPHREY

TWO pairs of interesting nerves associated with the nose of animals are the olfactory and the vomeronasal, or Jacobson's, nerve. The functioning of the olfactory nerve in the sense of smell and its central connections with the main part of the olfactory bulb have been recognized for many years. The specific function of the vomeronasal nerve, which arises from the specialized nasal epithelium known as the vomeronasal, or Jacobson's, organ and terminates centrally in that part of the olfactory bulb termed the accessory olfactory formation, is still somewhat of a mystery.

In recent experimental work Kahmann (11) showed that in certain lizards and snakes Jacobson's organ is used in trail following. Noble and Clausen (15) found the olfactory mechanism of greater effectiveness in the trail following of the garter snake than the vomeronasal nerve and organ, although these latter also played a part in such activity. According to Noble and Kumpf (16), hidden bait was trailed by the lizard, *Ameiva*, after destruction of either the olfactory or the vomeronasal organ of this animal. Wilde (17), using the garter snake, found by experimental methods that the vomeronasal nerves were essential to the strike response, which in turn was dependent on contact of the lips or the tongue with the stimulus. Since the vomeronasal nerve occurs in various forms other than the snake and the lizard, the question arises whether, when it is present, it always serves the same function. Moreover, since the vomeronasal nerve is related centrally with the accessory olfactory bulb, as shown by McCotter (12, 14) by gross dissection methods for the frog, the turtle (*Chrysemys*), the snake, the Gila monster, and a number of mammals (opossum, rat, guinea pig, rabbit, sheep, cat, dog), the relative size, development, and connections of the accessory bulb

become a matter of interest. The present account is concerned, then, with a description of the microscopic structure of the olfactory formation and, when present, the accessory olfactory formation in various reptiles, birds, and mammals.

The material used for this report has been stained with toluidin blue by the special Huber modification (Huber, 8) to bring out the nuclear patterns. In large part, series belonging to the G. Carl Huber Neurological Collection have been studied. This material has been supplemented, however, by several recently prepared series, among which is macaque material obtained through a grant from the Horace H. Rackham School of Graduate Studies, University of Michigan.

All the animals studied show a common pattern of olfactory formation, although this formation varies widely both in the degree of its differentiation and in its size. The arrangement as seen in the turtle, *Graptemys pseudogeographica* (Fig. 1), may be regarded as representative. Beginning at the periphery the following layers occur in order:

1. The layer of entering, unmedullated olfactory fibers, the fila olfactoria.
2. The glomerular layer, the region of synapse between the entering olfactory fibers and the dendritic terminals of the receptive neurons, chiefly the mitral cells.
3. The external granular layer, made up of an occasional outwandered mitral cell and granule cells; the latter cells overlap the glomeruli and sometimes extend outward as periglomerular or even intraglomerular cells.
4. The external molecular or plexiform layer, largely a region of passage of the dendritic processes of mitral and other neurons, among which processes are scattered granule cells and outwandered mitral cells.
5. The mitral cell layer, formed by the cell bodies of these characteristic receptive cells, which pick up the impulses through their dendritic terminals in the glomeruli and discharge, in part to the internal granular layer and in part to the olfactory tracts, through their bifurcating neuraxes.
6. The internal molecular layer, which carries neuraxes of mitral cells and processes of other neurons.

7. The internal granular layer, a reinforcing and, in some reptiles at least, a receptive mechanism as well (since certain of its cells send dendritic processes to the glomeruli; Crosby, 2). In forms above reptiles, as the more caudal portions of the olfactory formation are reached, the secondary olfactory fibers tend to accumulate around the ventricle, producing an internal white layer.

Fig. 1

FIG. 1. Drawing of a transverse section of the olfactory bulb of *Graptemys pseudogeographica*, from a preparation stained with toluidin blue. × 25. The structural patterns of the olfactory and the accessory olfactory bulbs are shown: *a*, entering nerve fibers; *b*, glomerular layer; *b'*, external granular layer; *c*, external molecular layer, containing outwandered mitral cells and also granule cells; *d*, mitral cell layer; *e*, internal molecular layer; *f*, internal granular layer. The black layer lining the ventricle (*v*) is ependyma

The accessory olfactory formation appears in the olfactory bulb either as an infolding toward the ventricle or as an eminence on the surface and, as has been stated before, is the region of termination of the vomeronasal nerve. The layering of the accessory olfactory bulb in *Graptemys* (Fig. 1) may be taken as an example of the structure of this accessory olfactory formation, although there is a wide range of variation in the degree of development in the forms considered. In the accessory bulb of this turtle all the layers characteristic of the olfactory formation are found; the internal granular is a direct continuation of the same layer within the olfactory formation, although on the lateral side (Fig. 1), at the region of transition, there is slight thinning out of this layer. In some forms, however, for example in the squirrel (Fig. 7), the internal granular layer associated with the accessory bulb is distinct from that of the olfactory formation.

Consideration may now be given to the relative size and relative differentiation of the olfactory and the accessory olfactory formations in various reptiles, birds, and mammals. In such turtles as *Graptemys* (Fig. 1) the olfactory and the accessory olfactory formations, through levels showing the latter, are about equally well differentiated, and,

Fig. 2

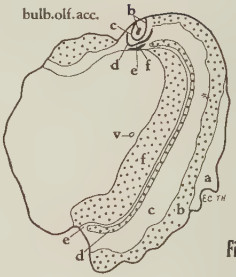

Fig. 6

Fig. 3

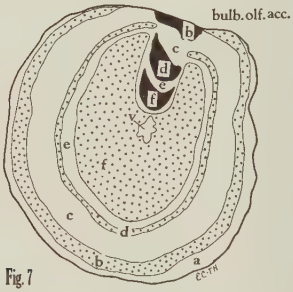

Fig. 7

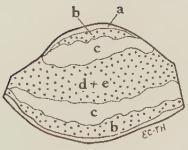

Fig. 4

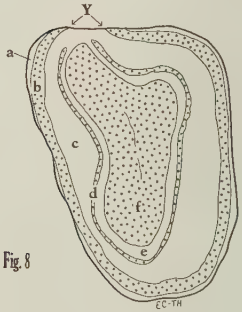

Fig. 8

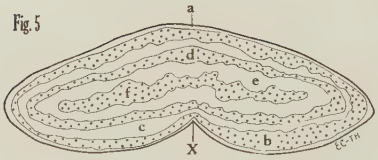

Fig. 5

FIGS. 2–8

For explanations of the figures see the bottom of the facing page.

in general, the turtle material at hand reveals no great variation in development for these formations.

In the available snake series, which include preparations of the garter snake, the copperhead (Fig. 2), and the water moccasin, the olfactory formation is quite typical at the rostral end of the bulb. After the appearance of the accessory olfactory bulb, which balloons out into the olfactory ventricle on the medial side, the greatly reduced olfactory formation is confined to the thin lateral wall. The accessory olfactory formation is very highly developed in these forms, with numerous mitral cells, many glomeruli, and large entering bundles of the vomeronasal nerve.

In the lizards an astonishing situation exists. On the one hand, in *Varanus* and the Gila monster conditions similar to those figured for the snake, but still more exaggerated, are found, for such olfactory formation as is present lies in the rostral end of the bulb, and behind this, at the level of the accessory olfactory bulb, in the very thin outer wall. Nevertheless, the olfactory bulb is very large, for the accessory olfactory formation is so enormous that in similar lizards it has recently been mistaken for the olfactory formation itself (Curwen, 3). Certainly the accessory olfactory dwarfs the olfactory formation. On the other hand, in such lizards as the American chameleon (*Anolis carolinensis*) and the horned toad (*Phrynosoma cornutum*, Fig. 3) the whole olfactory bulb is so minute that it is difficult to locate under the low power of the microscope and would be missed entirely if it were not so closely associated with the main mass of the forebrain. This minute bulb has a primordial internal granular layer and a few scattered mitral cells. Obviously no accessory olfactory formation can be recognized.

EXPLANATIONS OF FIGURES 2–8

Diagrammatic representations of the olfactory and the accessory olfactory formations in various vertebrates, with the layers of the accessory olfactory bulb alternately black and white and those of the olfactory formation alternately dotted and white. Fig. 2. Copperhead, × 25. Fig. 3. Horned toad, × 25. Fig. 4. English sparrow, × 25. Fig. 5. Crow, × 25. Fig. 6. Short-tailed shrew, × 12½. Fig. 7. Red squirrel, × 12½. Fig. 8. Macaque, × 12½

Explanation of lettering: *a*, entering nerve fibers; *b*, glomerular and external granular layers; *c*, external molecular layer; *d*, mitral cell layer; *e*, internal molecular layer; *f*, internal granular layer; *m*, mitral cells; *v*, ventricle; *X*, region of fusion of the olfactory bulbs in the crow; *Y*, denuded area, representing the position of the accessory olfactory bulbs in other forms

In forms such as the American alligator (Crosby, 2) no accessory olfactory bulb is present. In this reptile, however, the olfactory formation is very well and very typically developed.

None of the birds studied shows an accessory olfactory bulb, but there is a wide range in the differentiation of the olfactory formation. In some of the lower birds, such as the duck, the chicken, and the dove (Huber and Crosby, 9), the olfactory formation, although less in amount, resembles that of the alligator. The olfactory bulbs of the more highly specialized birds available were either greatly reduced in size, as in the parakeet (Huber and Crosby, 9), or separated rostrally and fused into a single mass caudally, as in the crow (Fig. 5, X), or reduced to a single bulb, as in the sparrow (Fig. 4). In these specialized forms the layers may still be fairly distinct, as in the crow (Fig. 5), or the mitral cells may be in the outer border of the internal granular layer, as in the sparrow (Fig. 4).

The variability in occurrence, size, and differentiation of the accessory olfactory formation and the degree of development of the olfactory formation characterizing the submammals find expression again in mammals. From the material studied this range of development in mammals is figured, and in the following paragraphs a brief description is presented of the olfactory and accessory olfactory formations in certain representatives of this latter class.

The accessory olfactory bulb has been described and figured in the opossum by McCotter (12) and by Herrick (7). Their descriptions have been checked on available series. In this form the accessory bulb is relatively large and characteristically differentiated.

In the red squirrel both the accessory olfactory formation and the olfactory formation (Fig. 7) are very highly and very typically developed. Here the accessory olfactory bulb is infolded rather than elevated on the surface, as in some mammals (opossum), but is clearly differentiable from the olfactory formation by the separation of its internal granular layer from that of the remainder of the bulb. In this form the vomeronasal nerve is large and enters near the caudal end of the accessory bulb at the region of infolding. The granular layer of the olfactory formation shows a specialization into a central, less differentiated, and a peripheral, more differentiated, region. The olfactory and the accessory olfactory formations in other rodents have been described (Gurdjian, 6; Young, 19).

The accessory olfactory formation of the newborn pig forms an

eminence on the dorsomedial surface of the olfactory bulb. It is actually larger than that of rodents, but proportionately smaller than the accessory olfactory formation of these animals, with layers not clearly separated from those of the olfactory formation and less distinctly differentiated. The olfactory formation of the pig is sizable and, in certain respects, very distinctive. It has many large mitral cells and an enormously developed internal granular layer, showing progressive differentiation from the ventricle toward the periphery.

A study of the olfactory and the accessory olfactory bulbs in the cat forms a part of a doctoral dissertation by Fox (5). These structures had been figured earlier for this carnivore by Winkler and Potter (18). Consequently they will not receive consideration here.

In the shrew (Fig. 6) the olfactory formation is well developed, with numerous glomeruli and well-differentiated mitral cell and granule cell layers, the mitral layer showing a double row of neurons and the internal granular layer exhibiting no undifferentiated central area. In contrast to this well-developed olfactory formation the accessory olfactory bulb is extremely minute. As seen in cross section, the tiny glomerular layer occupies the center of the infolded oval mass of the accessory olfactory formation and is completely surrounded by the narrow external granular layer. Here the mitral cells are very few and smaller than those of the olfactory formation. The internal granular layer is represented by a very small mass of gray. Since insectivores are supposedly in the line of development toward primates, this reduction in the accessory olfactory formation assumes phylogenetic significance, for up to the present, in the adult primates studied, no accessory olfactory bulb and no vomeronasal nerve have been identified in man and only rarely (and then tiny and unpaired) in the young macaque, although it is said that in the human embryo (McCotter, 13), and undoubtedly, then, in the embryos of other primates, the vomeronasal nerve is present.

In the bat the olfactory formation, which has previously been described from the available material (Humphrey, 10), is typically developed, but is small as compared with that of the shrew. No accessory olfactory formation is present in any of the bat series studied. However, in the region where one might expect to find an accessory olfactory bulb, an area denuded of olfactory formation may be observed.

In both the macaque (Fig. 8) and man the olfactory bulb is

reduced in size and in the cell content of the layers as compared with that of other mammals studied. The granule cells of the internal granular layer are very small, but show linear arrangement, with a thinning out in the center of the bulb, where the fiber tracts run. The mitral cells are few, but relatively very large, and slightly larger in man than in the macaque, a fact that does not provide for increasing specificity, although it may make provision for ample conduction of olfactory impulses. Moreover, the mitral cells do not form so definite a layer as in the subprimates studied, the layer being exceedingly indistinct, particularly in man. In these forms the glomeruli are small. The olfactory ventricle, which is present in the primate embryos, is obliterated in the young monkey (Fig. 8) and in man. In these primates, as in the bat, an area denuded of olfactory formation (Fig. 8, Y) marks the position which an accessory olfactory bulb might have been expected to occupy (and which it does occupy in the single macaque bulb in which it was found in our series).

SUMMARY

It is evident from the foregoing account that large, reduced, and minimal olfactory formations are found in representative reptiles, birds, and mammals. Among the reptiles, the turtles and the American alligator have a relatively large olfactory formation, and comparable conditions are met with in birds such as the duck, the chicken, and the dove, and in mammals such as the pig, the squirrel, the shrew, and the bat. Reduced olfactory formations occur in lizards such as the Gila monster and *Varanus*, in the snakes studied, in birds such as the crow and the parakeet, and, among mammals, in the macaque and in man. No whale material was available for study, but accounts in the literature indicate that the olfactory formation is either greatly reduced or absent in this mammal (Addison, 1). Minimal olfactory formations find representation also in the single olfactory bulb of the sparrow and, among reptiles, in the tiny olfactory bulbs of *Anolis* and the horned toad. Reduction in size to the minimal limit may or may not be accompanied by reduction in layer differentiation. Sometimes a reduced number of mitral cells may be compensated for by an increase in the size of the individual elements. For example, man has relatively few but exceedingly large mitral cells, a condition suggesting decreased specificity, even though providing compensation for conduction of impulses. In

brains having a minimal development of the olfactory system there is also a loss of specificity in pattern.

The accessory olfactory formation has by no means so wide a distribution throughout the group as has the olfactory formation. Thus, in the forms which have been studied, it is entirely lacking in the alligator and in certain of the lizards, in all the birds, in the bat, and in adult man. It is present, but greatly reduced, in the insectivores, is well differentiated in the turtles, and also in the pig, the squirrel, and the cat, and it reaches an exaggerated development in the snake and in some lizards. Certain points in regard to factors underlying its presence or absence are suggested from the series studied, although they need further documentation. No accessory olfactory bulb was found in any aërial form, whether bird or mammal, or in the human material studied. The experimental work mentioned previously (Wilde, 17, and others) suggests that the vomeronasal nerve and organ are employed by the snake in the strike response, elicited by contact stimulation of the lips or tongue, and in trail following. If such be the case, it would be apparent why a form such as the Gila monster might have a similar use for a vomeronasal organ, for, according to Ditmars (4), "the forked tongue is frequently employed to examine the ground over which the creature crawls." For certain mammals, such as the squirrel, the pig, and the cat, contact stimuli play an important rôle in obtaining food and, for the dog at least, in following a trail. Such mammals have well-developed accessory olfactory bulbs, as do the garter snake and the Gila monster, in which contact stimuli are so important for the functioning of the vomeronasal system. The erect position of primates would make the functioning of such a contact organ difficult, and the aërial habits of the bird and the bat would make it practically impossible.

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THE DISTRIBUTION OF COTTID FISHES IN LAKE MICHIGAN *

HILARY J. DEASON

MOST of the data upon which this paper is based were obtained during a comprehensive investigation of the selectivity of various sizes of gill-net mesh in relation to the catch of lake trout, *Cristivomer namaycush* (Walbaum), and lake chubs, *Leucichthys* species. The study was conducted on Lake Michigan during the years 1930, 1931, and 1932 by the United States Bureau of Fisheries in coöperation with the conservation departments of Michigan and Wisconsin. A descriptive account of the investigation has been published by Deason (1932), and Van Oosten (1933) has discussed some of the results.

The distributional records of Cottidae were largely obtained through the analysis of the food remains in several thousand stomachs of lake trout and lawyers, *Lota maculosa* (Le Sueur). Important items in the food of both these fish were three species of fresh-water sculpins (also known as cockatush, muddler, or miller's thumb), *Cottus cognatus* Richardson, *Cottus ricei* (Nelson), and *Triglopsis thompsonii* Girard (Van Oosten and Deason, 1938). *Cottus bairdii kumlieni* (Hoy), a fourth species known to exist in Lake Michigan (Hubbs, 1919a, 1919b, 1920, 1926), was not taken, presumably because it does not normally occur at the depths at which the lake trout and lawyers were collected.

On account of their small size sculpins are taken by the gill nets employed in the commercial fishery only on the very rare occasions when one becomes entangled by the fins, jaws, or preopercular spines. This circumstance undoubtedly accounts for the surprisingly few published records of Cottidae in Lake Michigan, despite their widespread distribution in the lake. Since the fish from which stomachs

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were removed probably had not traveled very far from the locality where the sculpins were taken, they provide distributional records which are considered fairly accurate. In this report there are used only those records which are based on specimens sufficiently intact to assure positive identification.

The identifications have been confirmed and some additional unpublished records provided by Dr. Carl L. Hubbs, curator of fishes in the Museum of Zoology, University of Michigan. Representative specimens of each species of Cottidae taken from lake trout and lawyer stomachs are deposited in the collections of the Museum of Zoology, University of Michigan, and of the United States National Museum.

Cottus bairdii kumlieni (Hoy)

Although *Cottus bairdii kumlieni* was not found in the stomachs of the lake trout and the lawyers from which the specimens for this study were obtained, known records of occurrence are mentioned here.

The earliest record of the subspecies in Lake Michigan, by Nelson (1876), was based on the type specimen, which had been collected and described in manuscript by Hoy. The stated locality, "deep water in Lake Michigan," seems questionable since no specimens of the species have subsequently been collected from deep water. As used, however, the term "deep water" may merely have indicated an offshore locality. Hubbs (1919b) reported the capture of a specimen in shallow water near Chicago.

These published reports and 18 additional captures provide distributional records for 102 specimens of *Cottus bairdii kumlieni* (Fig. 1). The unpublished records are as follows: near St. Ignace, August 3, 1919, by R. E. Ellsworth; near Petoskey, August 10, 1920, by A. M. White; Platte Bay (near Frankfort) and Grand Traverse Bay, in July, 1923, by John Van Oosten and Walter Koelz; off Michigan City, date and collector unknown; west of Mackinaw City, August 3, 1925, by C. W. Creaser; Lake Charlevoix, mouth of Carp River, Little Traverse Bay, and off Manistique, in 1926 and 1927, by Jan Metzelaar and assistants; three records from the mouths of creeks entering Green Bay, north of Menominee, in July, 1927, by John N. Lowe; three records from the mouths of streams west of Mackinaw City, in 1927, and one record from a creek mouth in Grand Traverse Bay, in 1936, by Carl L. Hubbs. Six specimens

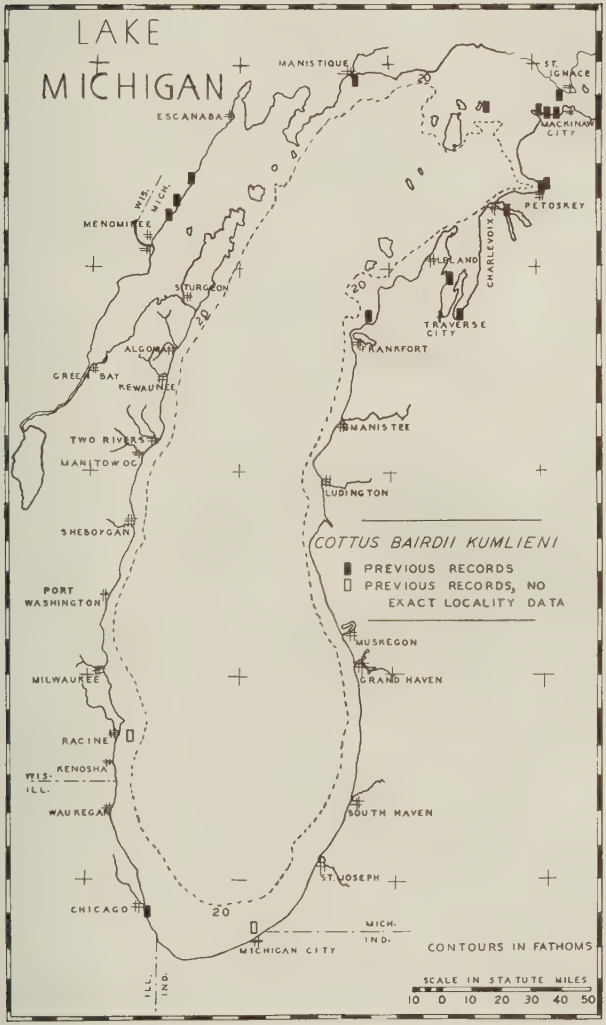

FIG. 1. Records of the distribution of *Cottus bairdii kumlieni* in Lake Michigan

collected off Hog Island by Elmer Brown on July 1, 1936, were taken from the stomachs of water snakes, *Natrix sipedon*. The aggregate of 102 specimens were all captured in less than 12 feet (2 fathoms) of water; the majority were in less than 6 feet. All specimens mentioned, except those of Nelson (1876) and Hubbs (1919b), are deposited in the Museum of Zoology, University of Michigan.

Since *Cottus bairdii kumlieni* was not found in the stomachs of trout and lawyers captured in Lake Michigan and since all known records are from very shallow water, it is concluded that the distribution of this large-lake subspecies of *Cottus bairdii* is confined in Lake Michigan to the inshore marginal areas and to the mouths of shallow tributaries. The subspecies is now known to occur in a few of the larger inland lakes of Michigan.

Cottus cognatus Richardson

Early records of *Cottus cognatus* in Lake Michigan were published under the name *Cottus franklinii*, but, as Hubbs (1926) has indicated: "It is no longer possible to separate the Great Lakes form called *Cottus franklinii* from the northern stream sculpin usually called *gracilis*. Furthermore, both of these nominal species appear to be synonymous with *Cottus cognatus* Richardson of the far north."

Three examples of *Cottus cognatus* were reported by Forbes and Richardson (1920) from a collection made by Forbes in deep water off Mission Point in Grand Traverse Bay in 1881. As noted by Hubbs (1926), these specimens were erroneously referred to *Uranidia kumlieni* through a misinterpretation of Hoy's description (as reported by Nelson, 1876) of a form now called *Cottus bairdii kumlieni* (Hoy). Another specimen was taken by the late T. L. Hankinson from the stomach of a lake trout caught on August 28, 1916, approximately nine miles west of Manistee, Michigan, by P. Peterson, a commercial fisherman. Greene (1935) reported *Cottus cognatus* from the mouth of a creek entering Lake Michigan immediately north of Sheboygan, Wisconsin.

A total of 272 specimens of *Cottus cognatus* was obtained from the stomach contents of lake trout and lawyers. These represent collections from 37 localities in Lake Michigan and Green Bay made between May and August in 1931 and 1932. The shallowest depth of capture of lake trout and lawyers whose stomachs contained the species was 13.5 fathoms (81 feet) and the maximum about 70 fathoms

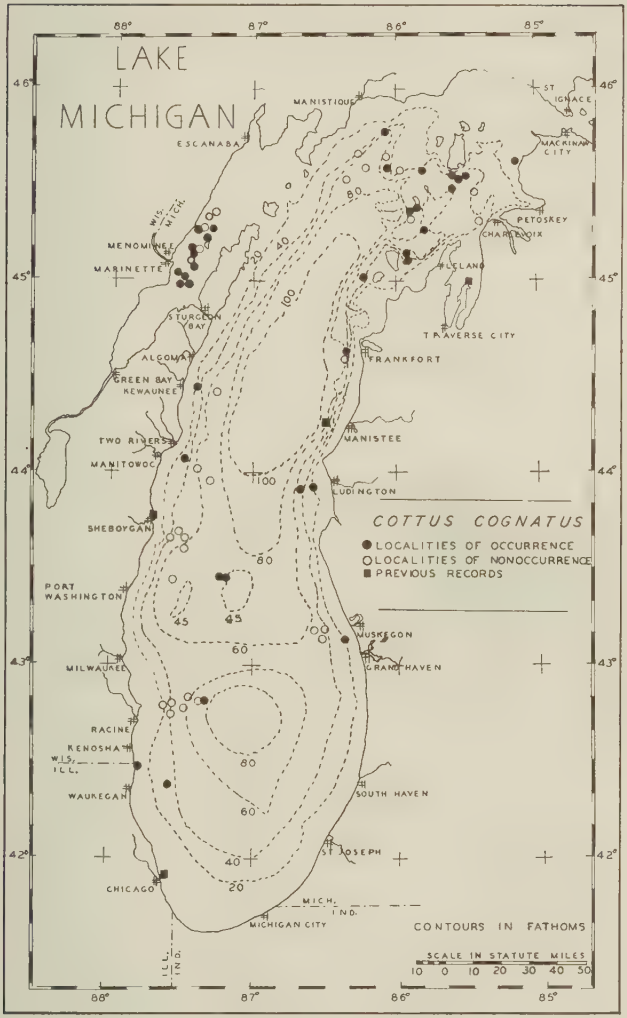

FIG. 2. Records of the distribution of *Cottus cognatus* in Lake Michigan

(420 feet). The localities where the predator species were captured — which must, therefore, be the approximate localities of occurrence of *cognatus* — are represented by solid black dots in Figure 2.

In addition to those records obtained from stomachs are two captures: one specimen taken by H. J. Deason and F. W. Jobes in a minnow seine operated from shore approximately abreast the Wisconsin–Illinois state line on June 7, 1931, at a depth of about 12 feet; and another caught by H. J. Deason in Green Bay, 7 miles E. $\frac{7}{8}$ N. of Menominee, Michigan, entangled in a gill net lifted on June 11, 1932, at a depth of 13 fathoms. The hollow circles on the map (Fig. 2) show the localities for collections of stomachs which did not contain this species of sculpin. Previous records, published and unpublished, are indicated by black squares. In the other figures hollow squares are used for records that lack exact locality data.

That *Cottus cognatus* occurs abundantly in many of the rivers and streams tributary to Lake Michigan is evidenced by numerous collections in the University of Michigan Museum of Zoology. The species appears to be somewhat more abundant in northern Lake Michigan than in the southern part of the lake, and probably ranges, bathymetrically, from near the shore to about fifty fathoms, but may occur occasionally at greater depths, as is indicated by records of capture off Racine, Wisconsin, and off Ludington, Frankfort, Leland, and Charlevoix, Michigan. The number of specimens taken at the different localities depended to some extent upon the number of lake trout and lawyer stomachs examined and, therefore, may not be an accurate index of natural abundance.

Cottus ricei (Nelson)

The original description of *Cottus ricei* (Nelson) was based on a specimen found on the shore of Lake Michigan near Evanston, Illinois (Nelson, 1876). Jordan and Gilbert (1883) described a specimen from "Lake Michigan, off Racine, Wisconsin," collected by Dr. R. P. Hoy, to which the name *Uranidea pollicaris* was assigned. The description checks in every detail with that for a typical example of *Cottus ricei*. Hubbs (1920) reported finding a specimen which had been washed up on the beach at Winnetka, Illinois (also north of Chicago). Dr. John Van Oosten, of the United States Bureau of Fisheries, secured three individuals from the stomach of a whitefish, *Coregonus clupeaformis* (Mitchill), caught in Pine Lake on August 12,

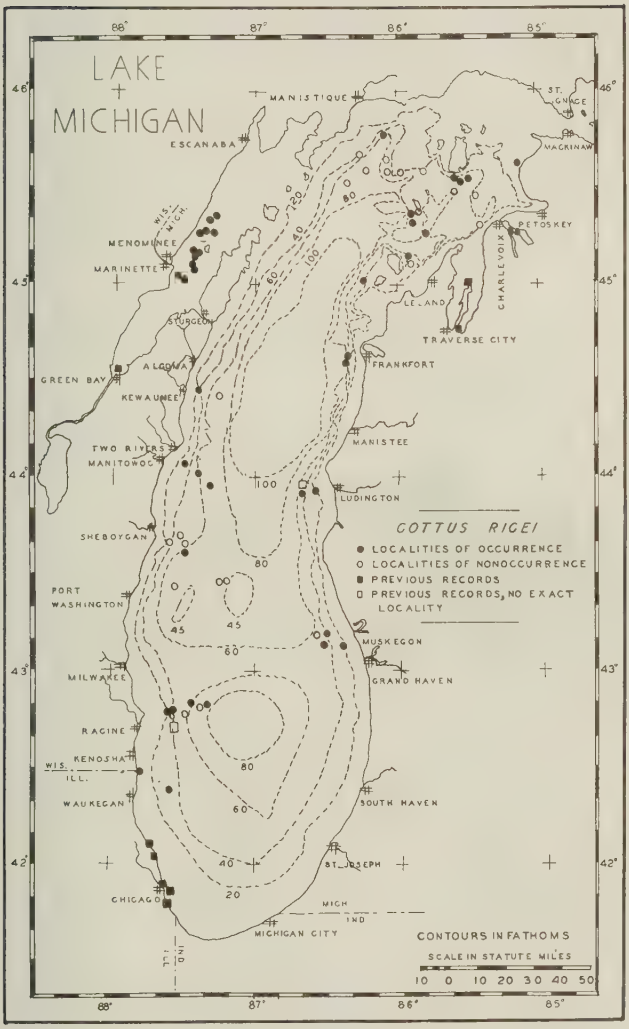

FIG. 3. Records of the distribution of *Cottus ricei* in Lake Michigan

1923, and obtained a single specimen from a small-mesh gill net set in Pine Lake in about four fathoms of water on August 10, 1923. (Pine Lake, now Lake Charlevoix, extends approximately southeast from Charlevoix, Michigan.) A single specimen was secured from Green Bay, near Green Bay, Wisconsin, in February, 1928, by a local game warden. Hubbs reports (unpublished) that he collected several half-grown individuals from about one foot of water near the head of the east arm of Grand Traverse Bay in June, 1930, and that he took one near shore at Jackson Park, Chicago, in the summer of 1918 or 1919.

The lake trout and lawyer stomachs examined contained 347 sculpins positively identified as *Cottus ricei*. The collections were made from April to September in 1931 and 1932 at 52 localities in Lake Michigan and Green Bay (Fig. 3). In addition to the records from stomachs, five specimens were entangled in gill nets lifted in Green Bay during June, 1932. This species was taken in nearly all areas of the lake from which stomachs were collected as well as in every locality in Green Bay. The shallowest depth at which the gill nets used to capture the predators were set was 13.5 fathoms (81 feet) and the maximum depth 73 fathoms (438 feet). A record from shallower depths was obtained by means of a minnow seine by Deason and F. W. Jobes on June 7, 1931, in 12 feet of water near the shore at a point approximately abreast the Wisconsin–Illinois state line.

As many as 33 specimens of *ricei* were obtained from a single stomach collection, but the number of specimens usually averaged less than 10 to a collection. The number of specimens was to some extent related to the number of stomachs examined and, therefore, may not be an accurate index of natural abundance.

The range of distribution of *ricei* in Lake Michigan appears to be from shore to about seventy-five fathoms. There are no records of the species from streams tributary to Lake Michigan.

Triglopsis thompsonii Girard

The first published record of the occurrence of this relict species in Lake Michigan, by Hoy (1872), was based on a specimen captured between 16 and 20 miles from Racine, Wisconsin, in 50 to 70 fathoms of water. Jordan and Thompson (1910) described and figured a specimen caught by Dr. Stephen A. Forbes in "Lake Michigan off

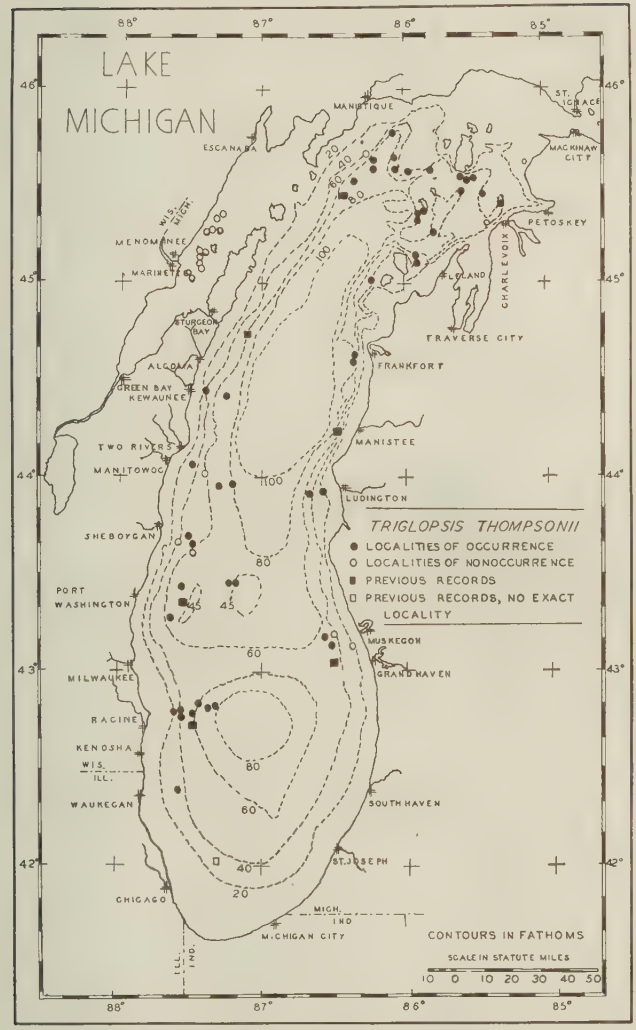

FIG. 4. Records of the distribution of *Triglopsis thompsonii* in Lake Michigan

Chicago," but did not state the exact locality. A total of 1,215 specimens taken from 65 collections of stomachs of lake trout and lawyers were identified beyond question as *Triglopsis thompsonii*. The great number of records for this species is due in part to the readiness with which partly digested and fragmented specimens can be identified by means of the bifurcate preopercular spine extremely characteristic of the species. As many as 139 specimens were secured from a single stomach collection, but on the average fewer than 10 were secured from 40 of the 65 collections and 10 collections contained between 10 and 83 specimens each.

Two specimens, 102 and 109 millimeters in standard length, found entangled in gill nets lifted on July 23, 1930, from 80 fathoms of water 31 miles southeast of Two Rivers, Wisconsin, were preserved by Deason (Catalogue No. 108083, University of Michigan Museum of Zoology). These are believed to be the largest individuals of the species reported from the Great Lakes. This record and one obtained from a specimen collected 14 miles southeast by east of Port Washington, Wisconsin, were made available to Greene (1935) for his distributional study of Wisconsin fishes.

The localities of occurrence of *Triglopsis thompsonii* in Lake Michigan are shown in Figure 4. In addition to the records from stomach collections and those mentioned above, six records obtained by others and not previously reported have been plotted on the figure. A collection of twenty-two specimens was made by the late T. L. Hankinson from stomachs of lake trout caught by a commercial fisherman, P. Peterson, "9 miles out of Manistee," where the depth is probably about 60 fathoms. Walter Koelz secured one specimen 12 miles west of Grand Haven, Michigan, on March 20, 1919; another 5 miles east by north of Charlevoix, Michigan, in 35 to 50 fathoms on June 20, 1920; five specimens 20 miles E. $\frac{1}{2}$ N. of Rock Island (slightly north of the largest and southernmost island of the group separating northern Green Bay from Lake Michigan proper) in 71 to 90 fathoms on August 19, 1920; two individuals 12 miles east by south of the Sturgeon Bay Ship Canal in 60 fathoms on August 23, 1920; and one 18 miles E. $\frac{1}{2}$ N. of Port Washington, Wisconsin, in 48 to 65 fathoms on September 25, 1920.

No representatives of *Triglopsis thompsonii* were found in Green Bay, where the waters studied were from 13.5 to 19 fathoms (81 to 114 feet) in depth, but the species was taken at a majority of the

localities where stomach collections of lake trout and lawyers were preserved in Lake Michigan proper. The distribution in the open lake appears, therefore, to range from approximately 25 to 100 fathoms (150 to 600 feet). The depth of greatest abundance is probably between 40 and 75 fathoms (240 and 450 feet).

United States Bureau of Fisheries
Ann Arbor, Michigan

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ANALYSIS OF THE COMPLETE FISH POPULATION FROM HOWE LAKE, CRAWFORD COUNTY, MICHIGAN *

R. WILLIAM ESCHMEYER

OVER a period of several years the Institute for Fisheries Research, Ann Arbor, Michigan, has been eradicating the fish in several Michigan lakes. With one exception these populations were almost valueless for angling because the fish were stunted and only a few had attained legal size. Three populations have been discussed by the writer (Eschmeyer, 1937, 1938); studies of several others have been undertaken, but have not yet been completed.

Howe Lake, unlike the lakes previously described, had a population of fish which were growing at a reasonable rate, were attaining a relatively large size, and were being subjected to a moderate amount of fishing. Studies of populations like that of Howe Lake are probably more valuable to our knowledge of fish management than are examinations of abnormal ones, but consideration must be given to anglers who have no objection to the eradication of fish which are valueless, especially if the lakes are to be restocked later, but who may be expected to protest if a good fishing lake is to be cleaned out. Removal of the fish from Howe Lake seemed to sportsmen to be justified because of the presence of carp. It is improbable that many such normal populations of fish will be studied in the near future by similar methods.

This discussion is, primarily, an analysis of the fish which were in Howe Lake at the time of the poisoning. It is based on a study of almost the entire population.

DESCRIPTION OF HOWE LAKE

Howe Lake is in Section 32, T. 27 N., R. 4 W., Crawford County, Michigan. It is about six miles west of Grayling, approximately a

* Contribution from the Institute for Fisheries Research of the Michigan Department of Conservation and the University of Michigan.

mile north of highway M.–76. It is on state-owned land and has no resort development. The surrounding country is a level sandy jack-pine plain, low in fertility and unsuited to agriculture.

A survey of the lake was made in the summer of 1937 by an Institute lake-survey party, consisting of Dr. David Chandler, Walter Crowe, and E. L. Cheatum. According to their measurements, it has an area of 13.4 acres at its current level, with a sandy margin and shoal and a peat bottom in the deeper water. The level has dropped decidedly in recent years and, in the opinion of Mr. Hans Peterson, district supervisor of fisheries operations, it is now about four feet below the level of ten years ago. It has a maximum depth of 24 feet and the basin is regular in form.

At the time of the examination in early August the water was unstratified. Temperatures were 76° F. at the surface and 72° F. at a depth of 21 feet. The colorless and moderately clear water gave a Secchi disc reading of 12.5 feet. It was quite alkaline (pH 8.1). The methyl orange alkalinity (51) was markedly lower than that of most alkaline lakes which had been previously examined by the Institute. The dissolved oxygen, which ranged from 8.3 p.p.m. at the surface to 6.0 p.p.m. at a depth of 21 feet, was adequate to support fish life at all depths.

Howe Lake is almost completely devoid of vegetation. A few stunted yellow pond lilies, a little *Chara*, and a small bed of pond weed (*Potamogeton sp.*) apparently comprise all the larger aquatics. Several of these forms have been introduced. Fish food, too, is scarce. A plankton net with a 10.5-centimeter diameter at the mouth yielded only 0.4 c. c. of plankton in a vertical haul to the surface from a 15-foot depth. Examination of food organisms taken by an Ekman dredge showed variation in volume of bottom organisms from 0.2 c. c. per square foot at a 5-foot depth to none at a 21-foot depth. Forage fish were relatively few.

HISTORY OF FISH MANAGEMENT AT HOWE LAKE

Much of the early history of fish management at Howe Lake is not known to the writer, but for recent years his information is probably complete. A number of species of fish have been introduced, and a variety of environmental adjustments have been made. According to reports, carp (*Cyprinus carpio*), which have been present for many years, were first planted in Crawford County in the period

from 1888 to 1892; they were possibly put into Howe Lake at that time. Efforts were made by the Grayling Fish Hatchery to use the lake to raise fish for stocking in other waters; hence several hundred adult small-mouthed bass (*Micropterus dolomieu*) were introduced as brood stock in 1926. The attempt met with indifferent success and was abandoned in 1935. In 1933 about 4,500 blunt-nosed minnows (*Hyborhynchus notatus*) were planted, and 20,000 more the next year. The lake was also stocked with 3,000 brook silversides (*Labidesthes sicculus*) in 1934 and 75 adult common suckers *Catostomus c. commersonnii*) in 1935.

Apparently none of the five species mentioned above was native to the lake. As will be noted later, the small-mouthed bass and the brook silversides had already been exterminated by 1937; carp and suckers seemed to be definitely approaching extinction, and the fifth species, the blunt-nosed minnow, was not especially well represented in the population. One bluegill (*Helioperca macrochira*) and one rock bass (*Ambloplites rupestris*) were found. These two specimens were probably introduced when young in one of the plantings of forage fish. Obviously they had no chances of becoming established.

The original population probably consisted of large-mouthed bass, common sunfish, perch, and darters.

Environmental "improvements" included the introduction of pond lilies and *Chara*, fertilization with stable manure, the installation of brush shelters for the protection of the young fish and of slabs for use by spawning minnows, and the provision of gravel for spawning beds. Attempts to increase the vegetation were relatively unsuccessful. The value of the fertilizing was not ascertained, but the slabs were used by the minnows in spawning. The shelters and the gravel apparently influenced the fish population very definitely, as will be noted later.

The Grayling Hatchery records of fish removed from Howe Lake for stocking in other waters, all bass fingerlings (both species), are as follows: 1931, 17,000; 1932, 27,000; 1933, 16,000; 1934, 21,000; 1935, 27,000. Fishing was prohibited from 1930 to 1933.

METHODS

On September 7, 1937, the fish in Howe Lake were killed with powdered derris root. About 186 pounds (approximately 14 pounds per acre) was used. The method of administering the poison was

similar to that employed elsewhere (Eschmeyer, 1937). It is almost certain that all fish were killed, since the dosage applied was relatively greater than had been successfully applied in other waters to annihilate all fish and since no live fish were found later.

The introduction of the poison and the collecting of fish were carried out with the assistance of the survey party which had examined the lake earlier in the summer, of employees from the Grayling Hatchery, and of Conservation Officer Harry Souders. Efforts were made to examine all fish, and a large number were preserved for study. The sandy shoal was ideal for collecting. All fish which were not preserved were counted, and species other than minnows, darters, young-of-the-year game fish, and a few suckers and carp were measured as well as counted. The collecting was continued for five days, although few fish were seen after the second day. Many of the darters did not float, and it is possible that some remained submerged in deep water where one could not wade. It is believed that almost all the fish (probably over 95 per cent) were secured for examination.

Unless otherwise indicated, the ensuing discussions concern only the fish poisoned in 1937. The fish for laboratory examination were preserved in formalin and were later transferred to alcohol. Measurements of fish were made after preservation except for those which were discarded immediately after they were collected.

During the poisoning of a lake the smaller fish tend to die first and are readily available for the larger ones. Apparently almost all the young fish taken from the stomachs had been swallowed but a short time before the death of the predators, since the processes of digestion had not gone very far. Fish taken from stomachs are, therefore, invariably included in the totals.

Measurements of standard and total length were made in millimeters, and the fish were weighed to the nearest gram on a Welch balance, except carp, which were measured in inches and weighed in pounds. Weight is generally expressed in both grams and pounds; length, in both millimeters and inches; in some tables, however, weight is expressed only in pounds, but the weight of some very small fish is indicated only in grams. In work on the rate of growth of fishes the metric system of measurement has almost invariably been used; in fish-production studies the data are generally expressed (in America) in pounds per acre. In this discussion an effort has

been made to express measurements in the most usable form; hence the inconsistencies.

Since the fish were taken in early September they were actually older in terms of growth than is indicated; fish of the I group (1 annulus), for example, had completed the greater part of their second growing season.

THE FISH POPULATION

The entire fish population is calculated to have been 23,528 individuals at the time of the poisoning. They had a total weight of about 510 pounds, approximately 38 pounds per acre. Data on the number and weight of fish of each species and of all species combined are shown in Table I.

TABLE I

NUMBER AND WEIGHT OF THE HOWE LAKE FISH, BY SPECIES

Species	Number	Weight in pounds	
		Entire lake	Per acre
Common sucker	37	96.7	7.2
Carp	13	211.0	15.7
Blunt-nosed minnow	484	4.9	0.4
Common sunfish	775	26.5	2.0
Large-mouthed bass	18,759	155.4	11.6
Perch	2,826	13.6	1.0
Darters	634	1.3	0.1
Totals	23,528	509.4	38.0

Carp ranked last in numbers but first in weight. They and suckers, both almost valueless for angling and of no value as food for other fish because of their large size, comprised almost two thirds of the population on a weight basis. Both species, however, would have become extinct, and it is probable that some years later the poundage of fish in the lake would have been much reduced with little or no injury to fishing. Large-mouthed bass ranked first in abundance and were undoubtedly the most valuable of the several species.

With the exception of forms represented by only one or two individuals and of the two kinds of darters which were not differentiated in the field each species is discussed separately.

Common Sucker, *Catostomus c. commersonnii*

A total of thirty-seven suckers, half the number reported to have been planted in 1935, was collected. Because of their large size it is improbable that any were overlooked. Eighteen taken at random measured 481 mm. (18.9 inches) and weighed 1,185 grams (41.8 ounces). The thirty-seven suckers weighed, therefore, approximately 96.7 pounds. Since the smallest fish had a length of 15.5 inches all were probably from the single planting.

The adult suckers had been planted as brood stock to provide food for bass and the other fish. No suckers are known to have been in the lake before the planting of the seventy-five individuals in 1935. Apparently this attempt met with complete failure, unless it be assumed that all the young from the two spawning seasons had been eaten by the time of the poisoning, because no small suckers were found. If the fish had reproduced successfully a few probably would have survived, even in a lake where food was scarce and where predatory bass were relatively abundant. Their apparent failure to reproduce may be partly explained.

Suckers generally prefer to spawn in streams, but they also reproduce successfully in many landlocked lakes. Perhaps spawning conditions were unfavorable in Howe Lake. Or the failure in reproduction may have been partly due to an abnormal sex ratio. Reighard (1920) states that the males precede the females to the spawning grounds and that during most of the spawning period only males are in the riffles. The Howe Lake suckers had been taken from the outlet of Lake Margarethe during the spawning run, and but few females may have been in the number which were introduced. Mr. Peterson states definitely that females were included, since eggs were flowing freely from some of the fish. The importance of determining the sex of the suckers in Howe Lake was not realized until after they had been discarded. If for some reason the females suffered early mortality, the lack of young may be due to the absence of this sex.

The number of young perch and bass would probably have been greater had the suckers reproduced successfully, for the young suckers would have replaced some of these fish as food for the larger bass.

The fish had grown from about 15 inches, the length when planted in 1935, to about 19 inches in 1937.

Carp, *Cyprinus carpio*

It is reported that carp were once numerous in Howe Lake, but that in recent years their number has declined. According to reports, a few were speared in 1933, and two years later a small one about nine inches long was taken with hook and line. So far as is known, no others have been removed in the last few years.

Thirteen large carp were collected after the poisoning. Nine of these had an average length of 33 inches and ten an average weight of 16.1 pounds. The thirteen fish had a combined weight of 211 pounds. There were no young carp; it is probable that eventually the species would have been eliminated even if further efforts to reduce their numbers by spearing had not been made.

The extent to which carp are injurious to other fishes still needs to be determined. In 1934 the bass nests in one end of the lake were from six to eight inches deep, and the gravel was more or less scattered. Elsewhere, on similar heaps of gravel, the nests were all of the usual saucer-shaped kind. It is possible that the condition of the nests in the one end of the lake was due to the effort of the carp to obtain what food might have accumulated on the gravel.

The general impression is that the carp were responsible for the relatively small yield of fish, but ecological conditions are such that the lake would not be exceptionally productive, regardless of the presence or the absence of carp.

The total weight of these thirteen carp was greater than the total weight of fish of any other species.

Blunt-nosed Minnow, *Hyborhynchus notatus*, and Other Minnows

Blunt-nosed minnows were probably not present until they were introduced in 1933. Observations since that time have failed to indicate that the species was at all abundant.

The forage fish which were discarded were not sorted by species, and the number of blunt-nosed minnows reported is based on the assumption that they were relatively as abundant in the forage fish which were discarded as they were in the random sample which was preserved, and also on the assumption that they were equally abundant in the stomachs of the bass and perch which were examined and in those which were discarded.

Of 193 blunt-nosed minnows and darters combined half (97) were of the former species. If we assume that half of those discarded were blunt-nosed minnows, 484 were present. Very few were found in the stomachs of the larger fish.

The preserved fish had an average weight of 4.5 grams and a combined weight of 2,178 grams, or 4.9 pounds. The ratio of adults to young in the sample was 5 : 1, a rather unusual ratio, since the young would normally be much more abundant than adults. Possibly not many young were hatched, but it is quite probable that, even if considerable young had been produced, their numbers would have been very decidedly decreased by the numerous bass and perch.

Five specimens of minnows other than the blunt-nosed were taken: two of *Nocomis biguttatus*, two of *Notropis d. stramineus*, and one of *Notropis cornutus frontalis*. It is assumed that these fish were introduced by anglers or were inadvertently planted with the blunt-nosed minnows.

Common Sunfish, *Eupomotis gibbosus*

Adult sunfish were not abundant, but were relatively large.

The distribution of the age groups of sunfish was unusual. Only twelve young of the year (0 group) were found. Of these, one was taken from a bass stomach, one was preserved, and the other ten were discarded. The lone preserved specimen had a total length of 40 mm. and a weight of 1.1 grams. The fish were of relatively uniform size and the total weight of the young was, therefore, only about 13 grams, or less than a half ounce.

The I group was represented by 733 individuals. Of these, 117 were preserved, 9 were taken from the stomachs of the adult bass, and 607 were measured in the field and discarded. Average length and weight, based on 116 preserved specimens, are: total length, 88.3 mm., or 3.5 inches; standard length, 70.8 mm., or 2.8 inches; and weight, 11.3 grams, or 0.4 ounce. The smallest specimen in this group had a total length of 70 mm.; the largest, 108 mm. The total weight of the 733 specimens was about 8,283 grams (18.3 pounds).

The proportion of 12 one-summer-old to 733 two-summer-old sunfish is obviously abnormal, but is easily explained. During the spawning season of this species in 1937 it was decided to destroy the nests. The eggs had been laid, but few if any had hatched. The method of destroying the beds was a crude one, consisting merely

of kicking the nests apart. A careful check of the number of beds which had been wrecked was not made, but it was between ten and twenty. Possibly not every nest was destroyed, and perhaps the eggs of a few may have hatched before this activity.

It cannot be shown that the destruction of the spawning beds was responsible for the small number of young, but it is improbable that the condition is due to any other cause. The method may prove entirely practicable in reducing the numbers of fish that are overabundant or of undesirable species, provided they nest in clear shallow water. The destruction of the beds in Howe Lake would have been done more carefully had the poisoning been anticipated.

Five specimens ranging in total length from 110 to 125 mm. were discarded, and their age was not determined. Possibly they were three-summer-old fish. Their combined weight is estimated at 125 grams, or about 4 ounces.

Of the adult legal-sized fish, 25 in all, 14 were discarded and 11 preserved. Those which were preserved ranged in size from 171 to 190 mm. and in weight from 119 to 159 grams. Efforts were made to determine the ages of these adult fish, but the scales could not be read with certainty, although the fish were apparently from three to five years old. These adults had an average standard length of 145.3 mm. (5.7 inches), an average total length of 180.1 mm. (7.09 inches), and an average weight of 51.5 grams (1.8 ounces). The total weight of the adult population was 7.9 pounds. Five of the preserved sunfish were females; six were males. The number, average size, and weight of the fishes in the several groups are shown in Table II.

TABLE II

NUMBER, AVERAGE TOTAL LENGTH, AVERAGE WEIGHT, AND TOTAL WEIGHT OF COMMON SUNFISH IN THE VARIOUS SIZE GROUPS BASED ON MEASUREMENTS AND WEIGHTS OF NUMBER OF SPECIMENS INDICATED IN TEXT

Age group	Number	Average length in inches	Average weight in ounces	Total weight in pounds
0	12	1.4	...	....
I	733	3.5	0.4	18.3
Age not determined (probably II)	5	...	0.8	0.3
Adults (II–IV)	25	7.1	1.8	7.9
Total	775	...	...	26.5

The total sunfish population consisted of 775 specimens, which weighed approximately 26.5 pounds. The ratio of two-summer-old fish to adults was 29 : 1; of one-summer-old sunfish to adults, about 1 : 2.

The coefficient of condition (K) [1] was determined for the preserved specimens. The 116 two-summer-old fish had an average coefficient of 3.09; the coefficient of 11 adults averaged 4.68.

Large-mouthed Bass, *Aplites salmoides*

Large-mouthed bass were more abundant than any other species and were the chief attraction for the angler. Small-mouthed bass (250 adults) had been stocked about 1930 and reproduced successfully, but by 1934 this species was no longer seen and by 1937 it had entirely disappeared. Whether its failure to become established was due to a lack of suitable spawning grounds (gravel had been introduced in 1930, but, with a lowering lake level, was probably not available at a desirable depth a few years later) or to some other cause could not be determined.

No young-of-the-year bass were removed by the hatchery in 1936 or 1937. Previously bass had been seined each year since 1931 and placed in other lakes in the vicinity.

Calculations indicate the presence of 18,759 bass having a total weight of about 155 pounds. These figures are based on the assumption that the fish which were discarded had the same average weight as those of the same age which were examined. Numbers and weights of bass of different age groups are given in Table III.

TABLE III

Number and Weight of Large-mouthed Bass in Howe Lake, by Age Groups

Age group	*Number*	*Total weight in pounds*
0	18,374	33.2
0 (cannibals)	229	8.6
I	25	6.8
II	10	5.2
III	105	78.8
IV	7	6.9
V and older	9	15.9
Total	18,759	155.4
Weight per acre		11.6

[1] For the formula see my earlier paper (1937).

A study of the young showed that cannibalism was prevalent and that some fish had grown very much more rapidly than others. Some study of cannibalism in bass has been made by Langlois (1936), who also summarizes papers on the subject by Cooper (1937) and others. These studies were all made in hatcheries or rearing ponds. So far as the writer is able to ascertain, no investigations of cannibal bass in natural waters have been made.

The question naturally arises whether or not the Howe Lake fish regarded as cannibals [2] were really young of the year. No annuli or irregularities which might possibly be construed as annuli were on the scales. The annuli on the older fish were readily noted, and there is no doubt in the writer's mind regarding the age of the fish considered cannibal young of the year. The largest cannibal studied was 18 mm. shorter than the smallest fish of the next oldest group (I). No such gap in size appeared, however, between the cannibals and the normal young. A large majority of the latter were between 50 and 60 mm. in total length. There were very few bass between 65 and 70 mm. in length, and 70 mm. was arbitrarily chosen as the dividing line between cannibals and noncannibals. This figure represents approximately the low point in the bimodal curve.

The fact that there is a wide range in the size of the cannibals suggests that some of them may have become cannibalistic earlier than others.

Of the normal young 6,872 were preserved and 11,459 discarded. In the stomachs of the larger bass which were examined there was a total of 43 bass of the 0 group. The number of young which were accounted for totaled, therefore, 18,374, or 1,371 per acre. On the basis of a study of 600 fish taken at random, they had an average standard length of 43.1 mm., an average total length of 53.9 mm. (2.1 inches), and an average weight of 0.82 gram. The entire lot weighed 15,067 grams (33.2 pounds).

The fingerling bass regarded as cannibals totaled 229, of which 108 were preserved for study. They had an average standard length of 89 mm., an average total length of 108 mm., and an average weight of 17.1 grams. The total weight of the cannibal population

[2] These fish might better be referred to as piscivorous or as fast growing. They undoubtedly ate fish other than bass; a few may have subsisted entirely on fish other than bass. Since the term "cannibal" is generally applied to such fish, it is used here also.

(229 individuals) was 3915.9 grams (8.6 pounds). On the average, a single cannibal weighed as much as 21 normal bass of the same age; the largest cannibal examined, as much as 49 normal fish. These data indicate that bass are capable of growing at tremendously different rates in natural waters as well as in hatchery ponds.

The larger cannibals were in much better condition than the smaller ones. The average K for the 108 specimens examined was 2.14; for the fish between 70 and 100 mm. long (36 specimens), 1.93; for those from 101 to 144 mm. (72 specimens), 2.23.

Howe Lake contained one cannibal to eighty normal young at the time the fish were collected.

Almost without exception the stomachs of the cannibals were distended, and the food consisted almost entirely of fish. In 116 stomachs (including those of 8 fish which were slightly smaller than those recognized as cannibals) a total of 168 fish were found. These consisted of 82 perch, 14 bass, 67 darters, 1 blunt-nosed minnow, and 4 unidentified (partly digested) fish.

To determine what percentage of the adult fish had been cannibals during the first year measurements were taken of scales from 27 normal young, 79 cannibals, and older fish which had been preserved. Key scales were invariably used. The scales of the young and the cannibals were measured from the center to the edge of the anterior field; measurements from older fish were taken only to the first annulus. These measurements, magnified 44.3 diameters, are shown in Table IV. The young and the cannibals had not yet attained a full year's growth; the zones would have been somewhat longer if the first annulus had had time to form. Normal growth during the first season was probably somewhat greater in earlier years (before 1936) because a considerable proportion of young were removed in those years by the Grayling Hatchery, and thus, presumably, more food was left for the remaining young. A study of Table II shows that the older fish (II to V groups) had not attained an exceptionally large size during their first year of life. In the I group about half the specimens had become relatively very large during their first year; in the II group only one had a large first year's growth. Of the legal-sized fish apparently only one had grown exceptionally large in its first year of life.

Several explanations might be given for the apparent fact that the older fish did not grow rapidly when young. Perhaps those

TABLE IV

GROUPING OF LARGE-MOUTHED BASS FROM HOWE LAKE ACCORDING TO THE LENGTH OF THE RADIUS OF KEY SCALES (MAGNIFICATION 44.3) TO EDGE OF SCALE FOR YOUNG OF YEAR AND TO FIRST ANNULUS IN OLDER FISH

Length of radius (× 44.3) by 3 mm. groups	Age group						
	Normal 0	Cannibal 0	I	II	III	IV	V
18–20.9	4	..	..	..	..	..	..
21–23.9	15	1	..	1	..	..	..
24–26.9	8	3	..	4	2	..	..
27–29.9	..	2	1	1	7	..	1
30–32.9	..	2	3	1	5	1	1
33–35.9	..	4	..	..	8	..	2
36–38.9	..	7	..	..	6	..	..
39–41.9	..	2	..	..	15	1	..
42–44.9	..	..	2	..	5	..	..
45–47.9	..	4	..	..	4	..	..
48–50.9	..	5	..	..	..	..	..
51–53.9	..	4	..	..	..	..	..
54–56.9	..	7	..	..	..	..	..
57–59.9	..	3	..	1	..	..	..
60–62.9	..	11	1	..	..	..	..
63–65.9	..	9	1	..	..	..	..
66–68.9	..	7	1	..	..	..	..
69–71.9	..	2	..	..	..	..	..
72–74.9	..	5	..	..	..	..	..
75–77.9	..	..	..	..	..	..	..
78–80.9	..	1	2	..	..	..	..
Total	27	79	11	8	52	2	4

which had been cannibals were more vigorous and were caught by the anglers or perhaps there was no cannibalism several years prior to the poisoning. Neither explanation seems suitable, however. Even with intensive fishing a few of the more voracious bass should have survived the angler and, since food had not been abundant for some few years at least, cannibalism was probably common each year.

A possible explanation, one which has considerable support in the literature, is the apparent relationship between growth and mortality. Schneberger (1935) found that some young perch had a very large first-year growth, but that similar growth was not noted in the older perch. Eschmeyer (1937) made the same observation for this species. In connection with the discussion of the causes of

Lee's phenomenon in a cisco population Hile (1936) quotes the literature as follows:

> The relation between individual growth rate and individual length of life has been studied experimentally by several investigators. Osborne et al. (1917) found that a temporary preliminary stunting delayed maturity and extended the life span of rats. Titcomb et al. (1928) and McCay et al. (1931) found that trout that did not grow lived longer than those which showed growth on a similar diet. Zabinski (1929) by effecting a retardation of growth was able to prolong life in the black beetle and the roach. McCay (1933) presented a brief discussion of the general problem of the relationship of rate of growth to longevity.

It is possible that these fast-growing individuals have an early mortality. The problem is an important one in fish culture, although little mention seems to be made of it in connection with the question of hatchery feeding. The general practice of obtaining in the hatchery rapid growth of those fish which require several years to reach legal size might be inadvisable. It is possible that in our northern waters such fish die from natural causes before they grow to the legal size.

TABLE V

Average Length, Weight, and Condition of Large-mouthed Bass from Howe Lake for Different Age Groups

Item	Age group					
	0	I	II	III	IV	V
No. of specimens	18,603	13	9	58	2	4
Av. standard length (mm.)	43.1	174.9	216.1	242.2	265.8	322.0
Av. total length (mm.)	53.9	210.5	258.7	290.9	320.5	385.8
Av. total length (in.)	2.1	8.3	10.2	11.5	12.6	15.2
Av. weight (grams)	0.8	123.1	234.5	338.4	442.3	802.7
Av. weight (pounds)	....	0.27	0.52	0.75	0.98	1.77
Av. *K*	....	2.24	2.30	2.38	2.28	2.40

Eighty-seven fish which were older than the young of the year were examined in the laboratory. Information on the age, length, weight, and condition is given in Table V. In addition to the 87 fish 69 were discarded after measurements had been taken. These 69 were placed in the age groups on the basis of length, but because of an overlap in size of different age groups a few may have been put in the wrong group. The number in each age group is shown in Table VI.

Except for the 0 group, which had not yet attained a full year's growth, the fish compare favorably in growth with those from other

waters, including more southern lakes, where growth might be expected to be more rapid. The specimens from Wintergreen Lake and Watkins Lake (see Table VI) were from relatively rich southern Michigan lakes, but the fish in these lakes grew no faster, in general, than those in Howe Lake. Bennett's extensive data indicate that fish in twelve northern Wisconsin waters grew, as a rule, at about the same rate as those from Howe Lake, i.e. more rapidly in some years and more slowly in others. The southern Wisconsin fish grew more rapidly than the Howe Lake fish. In view of the latitude the Howe Lake fish may be regarded as having grown at a moderately rapid rate.

TABLE VI

Comparison of the Growth of Large-mouthed Bass in Howe Lake and in Other Waters

Total length in inches

Lake	Date of capture	Age group					
		0	I	II	III	IV	V
Howe	September 7	2.1	8.3	10.2	11.5	12.6	15.2
Wintergreen *	Winter — various dates	4.0	8.7	11.3	11.7	12.0	12.7
Watkins †	September 29	3.1	...	9.5	10.7	....	13.6
Average for 12 lakes in northern Wis. ‡	Calculated for full growing season	2.8	6.5	9.7	11.7	13.2	13.9
Average for 4 lakes and 1 river in southern Wis. ‡	Calculated for full growing season	3.7	8.7	11.9	13.7	14.9	16.2

* Determined by G. P. Cooper (unpublished), Kalamazoo County, Michigan.

† Determined by Cooper and Eschmeyer (unpublished), Jackson County, Michigan.

‡ Determined by Bennett (1937); calculated lengths for the full growing season.

The unusual distribution of fish in the age groups cannot be explained on the basis of removal of young by the hatchery, since the figures on page 132 show no correlation. The number of fish removed each year in a four-year period and the number of fish in the remaining population for each year are shown in Table VII.

One change was made in the environment which might well ex-

TABLE VII

NUMBER OF FISH IN EACH AGE GROUP AND NUMBER REMOVED, AS FINGERLINGS, FROM EACH GROUP

Age group	Number of fish in age group	Year born	Number of young removed each year
I	25	1936	None
II	10	1935	27,000
III	105	1934	21,000
IV	7	1933	16,000

plain the abundance of fish in the group born in 1934 (III group). Gravel was introduced in the summer of 1933, and the number of young bass in 1934 may have been much greater than usual because of improved spawning conditions. The large number which survived from that spawning may have greatly reduced the number of fish born during the next several seasons by consuming a large percentage of them. The distribution of fish in the age groups suggests (though it does not conclusively prove) that the gravel may have been decidedly effective in increasing the number of bass. Because of the difference in seining intensity during the several years the number of young obtained each year by the hatchery is not an index of the abundance of young in the lake.

None of the I group had attained a legal length of 10 inches, but in the II group all except three were of legal length. The total number of legal-sized fish was, therefore, 128, or about $9\frac{1}{2}$ per acre. The 0 group had 18,603 specimens, including the cannibals, and the ratio of legal-sized bass to young-of-the-year bass was, therefore, 1 : 145. If the population had been uniform for several years the data could be construed as indicating that one adult might be expected to result from each 145 young (2.1 inches long). A considerable number of adults had been removed during the summer by anglers, but in that same period many young of the year were eaten by the other fish and by some of their own group. The ratio of game fish to forage fish was 20 : 1 at the time of the poisoning and, since other food appeared to be scarce, the young game fish were very probably the chief source of food for the larger ones. Since there are no data with which to compare these figures, no claim can be made that they are representative for bass in general.

Perch, *Perca flavescens*

Perch were second in abundance, but their weight was very small as compared with the total weight of fish in the lake.

The number of young (0 group) was 2,678, comprising 528 preserved specimens, 1,934 discarded fish, 200 in stomachs of bass, and 16 in the stomachs of larger perch. The last two figures are based on the assumption that the number of small perch in 195 bass and 41 larger perch was representative.

Two hundred specimens taken at random from the preserved lot (0 group) had an average standard length of 47.3 mm. and an average total length of 57.2 mm. (2.3 inches). Fifty females had an average total length of 58.3 mm. and 50 males had an average total length of 56.2 mm. Even during the first season the females were growing more rapidly than the males. The two sexes were about equally represented: of 108 individuals taken at random 57 were females and 51 males.

The 200 specimens had a weight of 319 grams. The entire lot of young-of-the-year perch (2,678 fish) weighed, therefore, about 4,218 grams (9.3 pounds). The ratio of young-of-the-year bass to young-of-the-year perch was approximately 7 : 1 (18,374 : 2,678).

Forty-three two-summer-old perch were preserved and 88 discarded. In a sample of 41 of these fish 15 were females and 26 males. The females averaged 92.4 mm. in standard length, 109.7 mm. in total length, and 12.2 grams in weight, and had an average K of 1.47; for males these figures were, respectively, 77.8, 93.5, 6.7, and 1.40. The fish had a total weight of approximately 1,140 grams, or 2.5 pounds.

Of the perch older than two summers 5 were preserved and 12 discarded. The discarded fish were measured, but sex determinations were not made. Because of the difference in growth of the two sexes it could not be determined from the measurements whether these fish were females of a certain age or males a year older. The five preserved specimens included three age groups. All had attained the legal length of six inches. The combined weight of the 17 specimens was about 822 grams, or 1.8 pounds.

Differences in the rate of growth of the two sexes of perch have been noted by Schneberger (1935) and others.

The entire perch population totaled 2,826, weighing 13.6 pounds.

This number includes 2,678 young of the year, weighing 9.3 pounds; 131 two-summer-old fish, weighing 2.5 pounds; and 17 adults, weighing 1.8 pounds.

Perch represented only one pound of fish per acre. The ratio of young to two-summer-old perch to adults was about 158 : 8 : 1.

Darters, *Boleosoma nigrum* and *Poecilichthys exilis*

There were two species of darters, but they were not differentiated in the fish which were discarded. A sample of 96 specimens contained 92 Johnny darters and 4 Iowa darters. Most specimens were, therefore, of the former species. If half the discarded "minnows" were darters, a total of 385 was discarded. If the stomach contents of the bass and perch discarded were similar to those of the bass and perch examined, the stomachs contained 253 fish. The total population was estimated, therefore, as 634 individuals. This figure is less reliable than are the data for other species, since the darters tended to remain on the bottom even several days after the poisoning. The estimated population, if similar in weight to the 96 preserved specimens, had a total weight of 588 grams, or 1.3 pounds.

TREND OF THE POPULATION

Within a period of four years the relative abundance of perch and bass changed very markedly. Frequent examinations (observations and fishing) by the writer in 1933 suggested that perch were abundant and that bass were relatively few. The perch, which were slender and had abnormally large heads, were obviously stunted. At the time of the poisoning in 1937 perch were far fewer than bass, with a ratio of about 1 : 7, and apparently were in better condition than the perch had been a few years previously.

The change in population is attributed to environmental "improvements," i.e. the providing of gravel for bass spawning and the installation of brush shelters which, according to limited investigation, are frequented more by bass than by perch. It seems probable that the number of bass increased as a result of these improvements and that they reduced the number of perch.

An examination of the stomachs of the larger fish suggests why the number of perch may have declined as the number of bass increased. When rotenone is used the young fish tend to die first and the larger fish are able to take their choice of the smaller ones. So

far as could be determined, both young bass and young perch died at about the same time. If they were eaten indiscriminately, the stomachs of the large ones should have contained seven young bass to one young perch, because that was the ratio of the fish. Actually, the ratio of bass to perch in the stomachs of larger fish was 1 : 4 (27 : 106). Cannibal bass, adult bass, and perch all showed a preference for young perch, with cannibal bass by far the most destructive to these young of the year. The young bass and young perch were of about the same length, but, naturally, were of quite different shape. This difference was probably the chief factor in the consumption of fish of the two species, but their location in the lake also may have been influential. The figures on relative abundance of fish in the stomachs are given in Table VIII.

TABLE VIII

Number of Perch and Bass (0 Group) in the Stomachs of Other Fish, per 100 Stomachs

Predator	Prey	Number per 100 stomachs	Prey	Number per 100 stomachs
Bass, cannibal.....	Bass	12	Perch	71
Bass, adult.....	Bass	10	Perch	23
Perch.....	Bass	5	Perch	12

Young perch were perhaps the chief food item of the older bass and perch at the time the lake was poisoned.

ANGLING

Had the poisoning of the Howe Lake fish been anticipated an intensive creel census would probably have been maintained on this lake during the summer. No estimate of the number of fish caught can be made. Mr. Peterson indicates that Howe Lake was fished heavily for several years during the early part of the fishing season, but that in the middle, and later, few fish were caught. He made inquiry of some of the anglers and learned that one party took 27 bass, 2 perch, and 6 sunfish in twelve trips to the lake. The writer caught 4 perch and 4 sunfish in three attempts. On a Sunday late in the summer, the lake survey party noted that of approximately twenty-five anglers only one had caught a bass. This survey party took

no fish in experimental gill nets placed in the lake for two days. The meager information suggests that over half of the fish may have been removed by angling. This is in striking contrast to the removal of fish in several southern Michigan lakes, where, it is estimated (Hazzard and Eschmeyer, 1938), less than 8 per cent of the available fish were removed by angling.

After all the fishing on Howe Lake over nine adult bass per acre remained. This number is probably ample for brood stock. It seems improbable that fishing by ordinary means reduces the number of fish to a point where an inadequate brood stock remains. Before that point is reached the catch probably becomes so low that angling is discouraged.

ACKNOWLEDGMENTS

The writer wishes to thank Dr. David Chandler, Walter Crowe, E. L. Cheatum, Hans Peterson and his assistants in the Grayling Hatchery, and Conservation Officer Harry Souders for assistance in poisoning the lake and in collecting the specimens; Dorothy Woodbury, Myrtle Moffett, and O. H. Clark for help in the laboratory; and Dr. A. S. Hazzard and Dr. Ralph Hile for valuable suggestions in preparing the manuscript.

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BIOLOGY OF CERTAIN SUBAQUATIC FLIES REARED FROM EMERGENT WATER PLANTS*

W. CARRINGTON FROHNE

DIPTERA constitute an interesting and important element of the insect population in the zone of emergent hydrophytes of north Michigan lakes (Frohne, 1938). In the present paper there are recorded life-history data of eight species, representing six families reared from five sedges and one reed. The requirements of life in this habitat appear to have induced a convergent evolution in physiology and habit among systematically remote flies belonging, some to the Orthorrhapha, others to the acalyptrate muscids of the Cyclorrhapha. One may see this by comparing, for example, the life history of *Hormomyia sp.*, a cecidomyiid, with that of *Cordylura latifrons* Loew, a scatophagid, or the adaptations of *Oligochaetus sp.*, belonging to the Dolichopodidae, with those of *Agromyza longipennis* Loew of the Agromyzidae.

The author wishes to acknowledge the help of Professor Paul S. Welch and the coöperation of E. P. Felt and the following authorities of the United States National Museum, who identified the Diptera and the hymenopterous parasites: R. A. Cushman, A. B. Gahan, C. T. Green, D. G. Hall, and C. F. W. Muesebeck.

1. *Asteromyia phragmites* Felt (Cecidomyiidae)

Felt (1936) described this gall gnat, partly from material collected during the present study from Crooked River and Maple Bay in the Douglas Lake region, Cheboygan County, Michigan. Indian River, Lancaster, and French lakes, Michigan, may now be added to these localities. The species is restricted, so far as known, to one food plant, *Phragmites communis* Trinius.

The egg stage is not known.

* Contribution from the University of Michigan Biological Station and from the Department of Zoology, University of Michigan.

The larva, which is light orange, was found in the emersed internodes of reed in winter and during all the warmer months, but it is scarce in July, when the adult is on the wing. The first instar was overlooked; the youngest stage collected was 1.35 mm. long. This size group, which was obtained in late July, lacks the breast bone, the characteristic larval structure of the family. The claim made by Comstock (1925), however, that in this family the breast bone is restricted to the last instar is not substantiated in this species by larvae of intermediate sizes. Individuals of 2.1–3.1 mm. possess a rudimentary breast bone 119 micra in length, which tapers posteriorly and otherwise differs from the typical structure in the grown larvae, 4.26 mm. long, of which the breast bone averages 255 micra long. All larval stages but the last are free-living in the internodal pith cavities, where they devour parenchyma and the vascular bundles which lie within the tough sclerenchymatous layer. They are markedly gregarious, since a score to several dozen feed in close association. Injury done by them sometimes results in yellowing of leaves, in failure to flower, or, most frequently, in stunting. These effects were quite evident by August 30, 1936, in Douglas Lake. When full-fed, last instar larvae spin hibernacula (cocoons) and become quiescent. For a long time these translucent silken constructions are white, but with the passage of months they assume a pale-brown hue. Typically the cocoons of the entire population of an internode are spun in a cluster, with their anterior ends together, so as to cover an emergence window area 0.5 mm. to several millimeters in diameter, where only the epidermis of the plant is left intact. Isolated cocoons were not observed. The larvae hibernate in the cocoons and remain quiet in the spring until about the middle of June, when the first pupations occur. In Douglas Lake about 25 per cent of the population had pupated by June 21, 1936. Three weeks later neither larvae nor pupae could be found there, owing to emergence of virtually the entire population. In the laboratory pupation and emergence took place in midwinter.

The pupa is typical. There is not, as in some gall midges, a puparium. Pupae are at first light orange, but become light brown, except the dark-brown eyes and wings. Total length is approximately 1.94 mm.; length from the anterior end to the tip of the abdomen, about 1.74 mm. The total length is the larger measurement because of the extension beyond the abdomen of the metathoracic legs.

Details of emergence are variable. Usually the pupa forces its way through one side of the elongate cocoon and the window to the exterior before disclosing the perfect insect. Some cocoon clusters, however, lack a window, and the pupa appears to be incapable of chewing a hole through the hard dry cane, and, indeed, as pupae neared emergence those which were experimentally confined in unperforated internodes were unable to escape. In nature pupal exuviae were found projecting from oviposition holes of *Epiurus sp.* (undescribed; Hymenoptera, Ichneumonidae). This ichneumon lightly parasitizes virtually every internodal micropopulation of *A. phragmites* in the situations studied. Thus the interrelationship of the two species often appears to involve mutualism as well as parasitism.

In addition to *Epiurus sp.* this cecidomyiid is host to an unidentified platygasterid and to the anomalous eurytomid, *Eurytoma? sp.* (undescribed).

2. *Hormomyia sp.* (Cecidomyiidae)

Authors have recorded sweeping species of *Hormomyia* from palustral grasses, which is perhaps the basis of Felt's statement (1913) that "There is good reason for believing that a number of species of *Hormomyia* live at the expense of plants of this natural order" (Cyperaceae). The present species was reared from elongate tuberous galls of culm bases of *Carex vesicaria* L., which were collected from Douglas Lake and Black Lake.

Infested culms of the sedge resemble young onion plants, owing to the swollen pale-brown or white unilocular, bilocular, or multilocular galls. Each locule is generally indicated externally by a secondary swelling and contains from one to three larvae.

The white or pink larvae are flattened dorsoventrally and are distinctly segmented by virtue of deep intermetameric constrictions. The short and wide breast bone is 102 micra long by 76 micra wide. It forks anteriorly into two prominent teeth measuring about one half of its length. The larval integument is regularly granulated.

Pupation takes place in the gall. The light-brown pupa is not further protected by a cocoon or puparium. Pupae measure 7.5 - 8.0 mm. long. The short legs reach only to the beginning of the seventh abdominal segment. The pupal period is sixteen days or more. Escape from the gall is by an upward migration; the perfect

insect afterward forces its way out of the stem above the level of the muck and probably above water as well.

A platygasterid, *Leptacis sp.* (probably new), was bred from galls of the midge collected in both localities.

3. *Oligochaetus sp.* (Dolichopodidae)

This small metallic-green dolichopodid is an abundant insect. Its decorative mines were observed in virtually every situation investigated in the Douglas Lake region, where it is a miner-borer in *Eleocharis palustris* (L.) Roemer & Schultes var. *major* Sonder, *Scirpus occidentalis* (Watson) Chase, and *S. americanus* Persoon. Nevertheless, the only reference known by the author to an American dolichopodid larva denizen in rushes, that of Hart (1895), clearly relates to some other species.

The egg and the first instar larva were not discovered.

The youngest elongate, cylindrical larvae did not exceed 2.0 mm. in length. The smallest larvae found closely resembled grown larvae measuring 7.0–8.0 mm. by 1.5–2.0 mm. All larvae have a vivid sulfur-yellow color, which is often accentuated by jet-black fecal material visible through the translucent smooth integument. The scarcely chitinized head is much less noticeable than are the long chitinized metacephalic and tentorial rods which extend well into the mesothorax. The mandibles are dark brown or black and fairly large. The literally invisible unchitinized spiracles are all lateral; there is no spiracular disk unless a pair of small anal prominences represent a rudiment of that structure. The most characteristic larval organs consist of seven ventrolateral swellings, each of which is almost intersegmental and provided with minute chitinous hooks of two types. The larger anterior hooks of each swelling are arranged in a single transverse row of about ten. Each is rodlike, 8–12 micra long and cleft at either end into two or three divergent prongs. Behind a row of rods a semicircular area of the swelling is studded with numerous microscopic spines in crooked or curved lines tending to be transverse.

The larvae produce characteristic caulonomia 2–10 mm. in diameter which are connected by deep-lying galleries. More ornate mines are produced in *Scirpus* than in *Eleocharis*, where nearly regular blotch mines occur in the most succulent culms. Individual grown larvae were found to have produced as many as six connected caulo-

nomia. The lowermost mine of such a series was regularly white in contrast to the older brown larval diggings higher up. Galleries are stained bright yellow and contain black frass. The larva is to be sought either completing the lowest mine or constructing a gallery below it. Larva and mines are generally in the top one third of a culm, either above or below water level. From ten to twenty larvae may infest a single bulrush culm, but there is seldom more than a single larva in one inhabited spike rush stem. Pupation takes place in a short gallery below the last mine. Unlike other aquatic long-legged flies, which are protected by cocoons, this pupa is naked. In northern Michigan the earliest pupa was collected on June 27 in 1936. The pupal was the most common stage during the first week of July.

The light-brown pupa measures 3.23 mm. in length by 0.82 mm. across the thorax. The head is slightly prolonged into a pointed beaklike rostrum, which is armed near its base with a stout bidentate median ventral horn about 120 micra in length. Rostrum and horn apparently aid the pupa to break the epidermis of the latest mine, by which avenue the adult reaches the exterior. The spiracles, including the prothoracic, are borne on finely corrugated elbowed spinelike processes 0.31–0.43 mm. long. Virtually the entire dorsum is beset with chitinous projections — setae and spines. Those of the thorax are setae of variable length, with the largest reaching 425 micra. On the dorsal aspect of the first abdominal segment these largest setae are lacking. Flattened spines located near the posterior border of each of the remaining abdominal somites increase from 34 micra long on abdominal 2 to 70 micra on abdominal 9. Concurrent with the anteroposterior increase in length of these spines is a decrease in their number from about 32 on abdominal 2 to 10 on segment 9. Furthermore, the abdominal segments bear dorsal setae about 120 micra long, rather evenly spaced at intervals of 30–60 micra. Finally, the abdominal integument, ventrally and dorsally, is finely shagreened with microscopic spinules.

Shortly before emergence the eyes darken markedly. The pupal period is from ten to fifteen days, and decidedly moist conditions are requisite for emergence and postemergence development.

Oligochaetus sp. is not known to be parasitized, though *Dacnusa sp.* (Hymenoptera, Braconidae) was reared from its mine. Difficulties in rearing the flies in small vials interfered with parasite studies.

4. *Cordylura latifrons* Loew (Scatophagidae)

Johannsen (1935) reported that "A specimen of *Cordilura praeusta* was reared from a puparium found in water in a swamp near Ithaca, New York, in company with some tabanid larvae" and adds: "The presumption is that the larva also is aquatic." No other reference to *Cordylura* in an aquatic environment was found.

Cordylura latifrons is a common stem borer of bulrushes in the Douglas Lake region. Larvae and pupae were collected in the proximal 15 cm. of the stems of *Scirpus occidentalis* (Watson) Chase, *S. validus* Vahl, and *S. americanus* Persoon. A few larvae, probably of this species, were encountered in *Carex vesicaria* L. The bulrush stands infested were those of Hook and Sedge points in Douglas Lake, Crooked River, and Crooked, Black, and Lancaster lakes. The adult was not seen in the field. This is not the abundant *Cordylura sp.*, which may be observed throughout the warm season as it plays hide-and-seek in the bulrushes. During this investigation no clue was obtained of the life history of this very common species, which is probably more aquatic than *C. latifrons.*

Larvae of *C. latifrons* ranging in size from about 2.0 to 12.0 mm. by 0.4 to 2.4 mm. were not observed to differ markedly in habits. The galleries of smaller larvae are usually tinged with claret, whereas those of older larvae are most often brown. A fine brown frass is noticeable in the older galleries. All classes of larvae exhibit a decided predilection for the white succulent growing base of the culm, in which small larvae bore irregular galleries extending from side to side; large individuals devour most of this vital tissue before attacking the overlying green zone. As a result, such culms stop growing, slowly wilt, and die. Reared larvae increased from 1 to 3 mm. a week and throve on water-soaked rotten segments of bulrush. No evidence was found to indicate a larval change of culms. Pupation takes place in the rotten culm base just beneath the epidermis which, however, is generally ruptured. A pupal window is indistinguishable, though the grown larva appears to prepare an irregular thin area through which emergence may take place. In the laboratory larvae pupated normally under water in vials.

The grown larva is sordid white, fusiform, and largest in diameter before the middle. The pharyngeal skeleton is similar to that of *Hydromyza confluens* Loew, figured by Johannsen (1935), from which

it differs as follows: (1) The mouth hooks are relatively (as compared with their dorsal and ventral processes) 1.5 times larger in *C. latifrons;* (2) the dorsal processes are stout rather than tapering; and (3) they extend no farther caudad than does the heavily chitinized part of the ventral processes. The spiracular disks of the last abdominal segment are pale yellow, separated by a distance equal to or greater than their diameter, and each bears three subequal digit-like caudal processes.

The puparium, which is 7–9 mm. long, varies in depth of color from pale brown to dark mahogany. It is sometimes nearly unicolor. More often it bears segmental darker markings or longitudinal stripes, which are more pronounced at the ends of the puparium. The thoracic segments and two anterior abdominals are transversely wrinkled, particularly on the venter. The fore half of the transitional third abdominal bears transverse wrinkles also, but the posterior part of this segment and all succeeding abdominals are longitudinally wrinkled. The prothorax bears a fan-shaped pair of anterior respiratory organs which are fringed with about forty finger-like projections. The rounded trapezoidal heavily chitinized anal plate is more than twice as wide as long. The length of its posterior border is about twice that of its anterior border. Between the anal plate and the posterior spiracular plates lie eight short, irregular, puckered pigmented projections — an anterior row of three pairs and a single pair posterior to them.

In July the pupal period of reared material was two weeks or slightly longer. Later in the summer a greater but variable duration of the period appears to be the rule. September puparia generally, perhaps always, hibernate. Larvae also overwinter.

C. latifrons is parasitized in the larval state by *Aphaereta sp.* (undescribed; Hymenoptera, Braconidae). The wasps emerge from the puparium of the host.

5. *Chloropisca sp.* (undescribed; Chloropidae)

A single individual was reared from a puparium found in a gallery of *Archanara subflava* Grote (Lepidoptera, Noctuidae), in *Scirpus validus* Vahl at Black Lake. Possibly the species is a scavenger in semiaquatic situations, since the puparium came from a rotted culm below water level. Dr. D. G. Hall, who determined the insect, is preparing a description.

6. *Diplotoxa microcera* Loew (Chloropidae)

The adults frequently appeared in vials containing bulrush spikelets and egg clusters of *Occidentalia comptulatalis* (Hulst) (Lepidoptera, Pyralididae), from North Fishtail Bay and Black Lake. The moth eggs were apparently not the food of the larva, however, and neither galls (such as are known to be produced in *Phragmites* by a European chloropid) nor any other evidences of larval activity were observed.

7. *Leucopis griseola* Fallén (Ochthiphilidae)

This species is almost certainly a predator of *Rhopalosiphum prunifoliae* (Fitch) (Homoptera, Aphiidae). A single puparium was obtained on August 12, 1936, at Crooked Lake, where the aphids were extremely abundant. The fly emerged on August 24, 1936.

8. *Agromyza longipennis* Loew (Agromyzidae)

In many lakes of southern Michigan this subepidermal miner in bulrushes is quite common. Its varicose elongated blotch mines were rarely found in northern Michigan in the culms of *Scirpus occidentalis* (Watson) Chase, and *S. americanus* Persoon. The mines are advanced downward, and both larvae and pupae were often collected below water level. The grown larvae, which are green, measure about 7 mm. in length. The puparia are shorter, about 5 mm. long by 2 mm. wide. Duration of the pupal period in early August is fifteen or sixteen days. Detailed studies of *A. longipennis* will probably demonstrate similarity in structure and life history to *A. laterella* Zetterstedt on iris, which was investigated by Claassen (1918).

SUMMARY

Data on the life histories of dipterous insects belonging to the fauna of the zone of emergent hydrophytes in lakes of northern Michigan are recorded. The following species are included:

1. *Asteromyia phragmites* Felt (Cecidomyiidae) inhabits the internodal pith cavities of *Phragmites communis* Trinius. Larva and pupa are described. Three hymenopterous parasites were reared.

2. *Hormomyia sp.* (Cecidomyiidae) produces tuberous swellings on the culm bases of *Carex vesicaria* L. Larva and pupa are characterized. One parasite was reared.

3. *Oligochaetus sp.* (Dolichopodidae) mines and bores in spike rush and bulrushes. Larva and pupa are described.

4. *Cordylura latifrons* Loew (Scatophagidae) bores in the culm bases of bulrushes. Larva and puparium are described. A braconid parasite was reared from the puparium.

5. *Chloropisca sp.* (undescribed; Chloropidae).

6. *Diplotoxa microcera* Loew (Chloropidae).

7. *Leucopis griseola* Fallén (Ochthiphilidae).

8. *Agromyza longipennis* Loew (Agromyzidae) mines subepidermally in bulrushes.

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AN UNUSUAL CESTODE RECORD FROM THE PORCUPINE IN MICHIGAN

W. CARL GOWER

INTRODUCTION

IN DECEMBER, 1937, the liver of a porcupine (*Erethizon dorsatum dorsatum*), heavily infected with larval tapeworm cysts, was received by the Game Division Laboratory from the Baldwin Headquarters of the Michigan Department of Conservation. The material was preserved in formalin. Since a preliminary examination of these cysts and their larvae showed them to be unique in a number of characters, a detailed study has been made.

A search of the literature reveals only one previous record of a larval tapeworm from a porcupine. Schwartz (1924) named *Taenia twitchelli* a new species of proliferating larval cestode from the lungs of a porcupine taken in Alaska. Recently McIntosh (1938) has described the adult of this species from the intestine of the Alaskan wolverine.

The following description is based on a careful study of sections of cysts as well as of whole mounts of the larvae. The hooks were studied in lactophenol. The characters of the larvae are considered sufficient to distinguish the tapeworm from all known species, and the name **Taenia michiganensis,** sp. nov., is suggested.

TAENIA MICHIGANENSIS, SP. NOV.

Specific diagnosis. — Adult unknown. Larvae (Pl. I) occur in thick-walled cysts composed entirely of host tissue, each cyst containing from one to ten larvae. Externally the diameter of the cysts ranges from 8 to 18 mm. There is no parasite "cyst." Plate II illustrates the external appearance of the cysts. For the most part the wall is composed of fibrillar connective tissue, but is infiltrated with leucocytes of various types. The number of leucocytes increases toward the interior of the cyst, and many occur, apparently free, in the cyst itself. Of the leucocytes, eosinophiles represent at least 25

per cent. No evidence whatever was found of a cyst comparable to the cyst of *Echinococcus* or of *Taenia multiceps*. The thickness of the cyst wall ranged from 0.5 to 0.8 mm. The individual larvae are in no way connected with the wall or with one another, and they float free as soon as the cyst is opened. The cysticerci measure 1–2 mm. in width and 2–4 mm. in length. They vary from spherical to long-oval and pear-shaped, the latter shape being more prevalent. The scolex is a typically inverted head; it measures 0.27–0.33 mm. wide and 0.37–0.48 mm. long. The suckers are 140–160 microns in diameter. There are 48–52 hooks, arranged in a double row. The diameter of the circlet of hooks is 96 microns. The large hooks (Fig. 1) are 30–32 microns in length, with a relatively short curved blade and a long narrow handle. The guard is heavy and thicker than the handle, and is 9.6 microns long. The small hooks, which are replicas of the larger ones, are 27–29 microns in length. There is relatively very little difference in the size of the hooks.

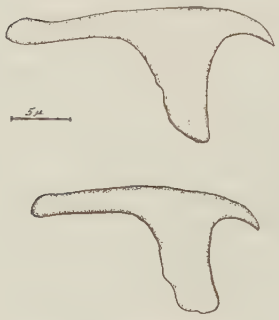

Fig. 1. Hooks of *Taenia michiganensis*, sp. nov.

Host. — Intermediate, porcupine (*Erethizon dorsatum dorsatum*); final, unknown.

Location. — Liver.

Distribution. — Michigan.

Type. — U. S. Nat. Mus. Hel. Col., no. 9189. Paratype no. 9190.

DISCUSSION

Taenia michiganensis differs in a number of characters from all described larval tapeworms of the genus *Taenia*. In the size of the scolex, suckers, and hooks it is only about one third as large as any of the described species of *Taenia*, and is only slightly larger than *Echinococcus granulosus*. The larva is a typical cysticercus, and does not show any character that might place it as an echinococcus or a coenurus type except that some cysts contained more than one larva. The larvae were not connected in any way with the cyst wall or with one another, and when removed from the cyst were perfectly formed cysticerci. These facts, together with the relative equal size

of the larvae (whether one or ten in a cyst), seem to indicate that each cysticercus developed from a different larva, the occurrence of more than one larva in a cyst being due to the mere chance of two or more larvae becoming embedded close together in host tissue. The presence of only one larva in a majority of the cysts bears out this supposition. In view of the data presented this cestode is considered a new species. The adult will probably be found in the coyote or the bobcat.

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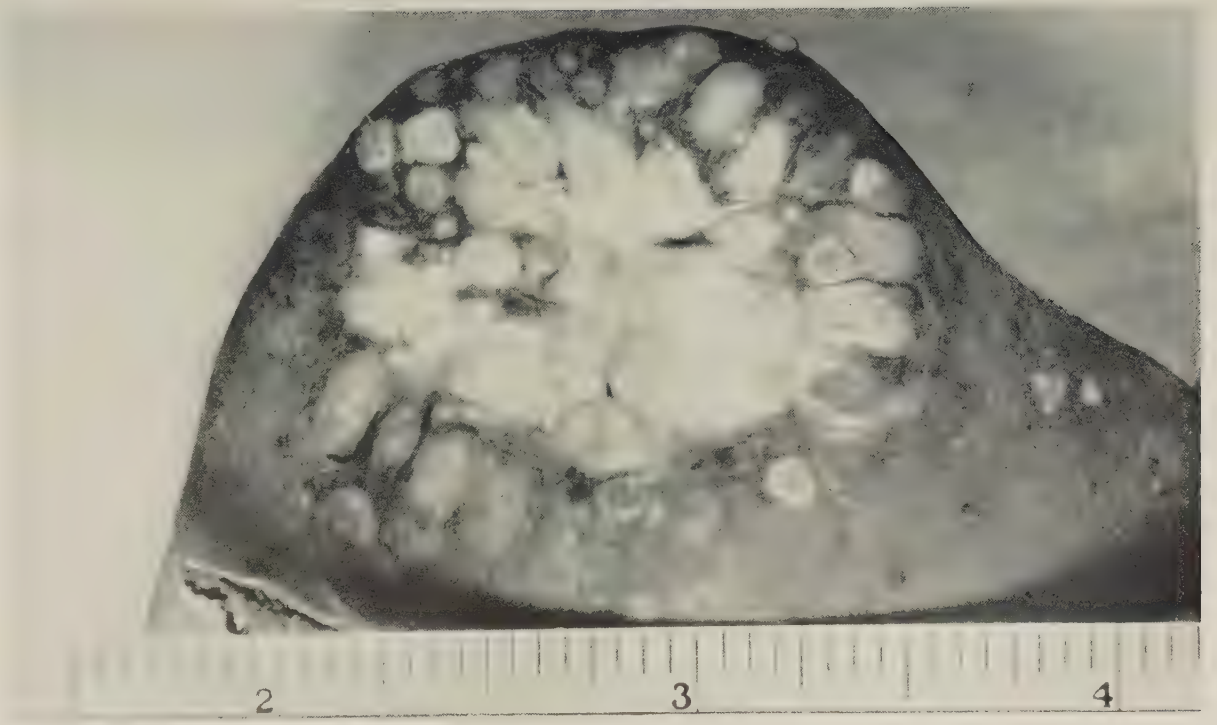
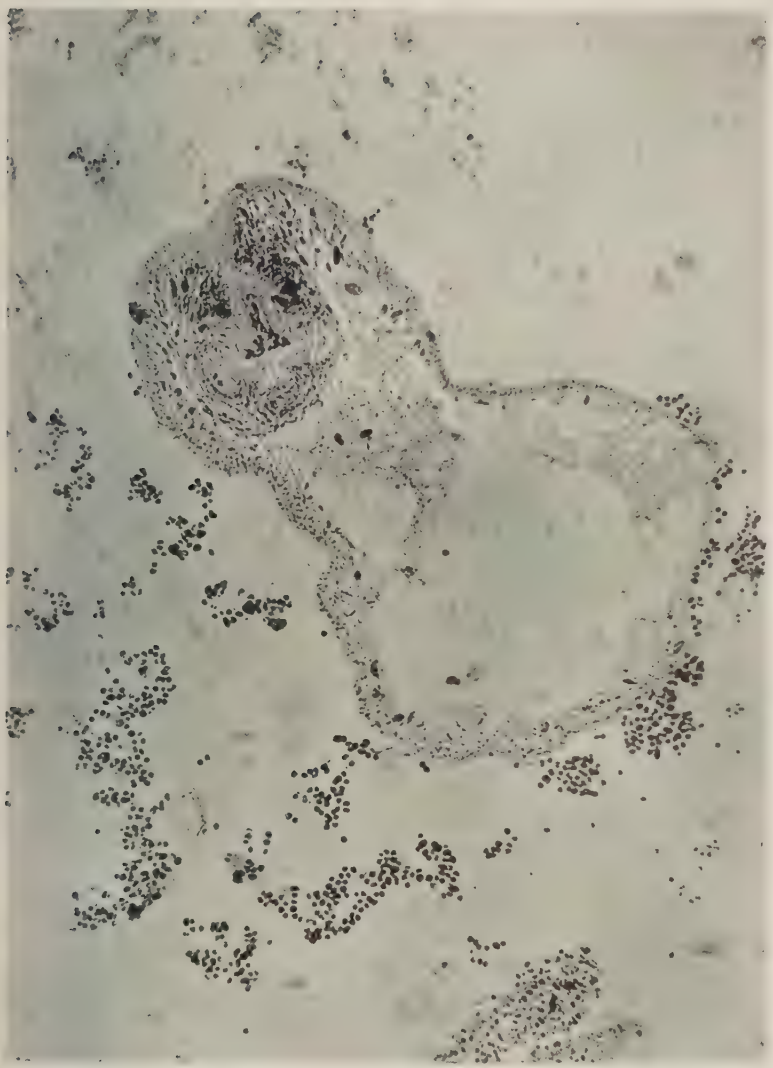
PLATES I–II



Part of lobe of porcupine liver heavily infected with *Taenia michiganensis*, sp. nov.



Photomicrograph of a longitudinal section of a cysticercus of *Taenia michiganensis*, sp. nov. The numerous cells around the larva are leucocytes

THE CHARACTERS AND DISTRIBUTION OF THE ATLANTIC COAST FISHES REFERRED TO THE GENUS *HYPSOBLENNIUS*

CARL L. HUBBS

IN ORDER TO provide a more adequate means for the separation of the species of Atlantic North American blennies referred to the genus *Hypsoblennius* and in order to be able to state their ranges more precisely, I have studied the pertinent material in the United States National Museum and the Museum of Zoology of the University of Michigan. So far as is apparent, the generally copied or abstracted account of these species by Jordan and Evermann (1898 : 2386–2390) is correct in its synonymy and in some of the characters described, but the features employed in their key are almost useless. Specific differences in the supraorbital cirrus, if such exist, are obscured by sexual dimorphism and individual variation, and the other characters used in the key are not alternative.

The two species of eastern North America now classed in *Hypsoblennius* are very readily distinguishable by several characters (see Table I), most of which have been overlooked.

Some of these distinctions between *H. hentz* and *H. ionthas* are trenchant enough to cast doubt on their generic unity, but a consideration of their generic identification should await a review of the whole group.

The range of *H. hentz* was incompletely indicated by Jordan and Evermann and most subsequent authors as "coasts of North and South Carolina, south to Indian River, Florida." The valid records of *H. hentz* from Cape Charles City, Virginia (Bean, 1891 : 85, as *H. punctatus*), and from Corpus Christi, Texas (Evermann and Kendall, 1894 : 119, as *Isesthes hentzi*), were overlooked. The record of this species from the Gulf of Mexico (Goode and Bean, 1882 : 236, as *Isesthes punctatus*) could not be confirmed by an examination of the material in the National Museum. Both *H. ionthas* and *H. hentz*

TABLE I

Comparison of the Characters of Two Species of *Hypsoblennius*

	Hypsoblennius hentz	*Hypsoblennius ionthas*
Lower lips	Almost linear; widely separated by a smooth area	Semicircular; separated by a broad shield-shaped lobe
Upper lip	Thin; in profile extending downward and slightly forward	Thick; in profile extending downward and slightly backward
Gill membrane	Forming a very slight fold across isthmus when head is not thrown back	Forming no trace of a fold across isthmus
Head	Longer; length contained less than 3.5 times in standard length	Shorter; length contained more than 3.5 times in standard length
First 2 (swollen) anal spines in breeding males [1]	First spine shield-shaped, broader than long, with a transverse fold on each side near base; second spine baglike	Both spines lanceolate
Angled light bar behind and below eye	Usually indistinct	Usually conspicuous
Dark spots in male	Conspicuous over head and trunk	Absent or scarcely developed except in suborbital region
Dark spots in female	Less distinct than in male, often inconspicuous, but developed over head and trunk	More distinct than in male, and always well developed, but confined to lower part of head
Size	Larger (largest one examined, 104 mm. in standard length)	Smaller (largest one examined, 66 mm. in standard length)

were recorded from Cameron, Louisiana, by Weymouth (1910 : 141), with notes on their sexual dimorphism and synonymy. Recently a specimen of *H. hentz* was recorded (Hubbs, 1936 : 283) from the Yucatan Peninsula at Champotón, Campeche, as *Hypsoblennius*, sp.

[1] In *Chasmodes* and *Hypleurochilus*, as contrasted with *Hypsoblennius*, the padlike anal spines bear conspicuous longitudinal striae. This distinction is shown in Hildebrand and Cable's recent figures (1938, figs. 74, 90, and 110). These authors furnish the best available description of *Hypsoblennius hentz*, but do not treat *H. ionthas*.

Therefore the distribution of *H. hentz* is much wider than is generally assumed. It ranges from New Jersey (Fowler, 1920 : 166) and Chesapeake Bay (Hildebrand and Schroeder, 1928 : 334) to Yucatan. *H. ionthas*, the other species of eastern North America, is limited, so far as is known, to the coast line from South Carolina to Texas (as stated by Jordan and Evermann).

Since the ranges of *H. hentz* and *H. ionthas* have been poorly understood and since that of *H. hentz* has been unduly abbreviated in the manuals and check lists, there is included in this paper a list of the specimens examined in the National Museum (by courtesy of Dr. Leonard P. Schultz) and in the Museum of Zoology of the University of Michigan. Each entry is headed by the catalog number and, in parenthesis, the number of specimens.

MATERIAL EXAMINED IN MUSEUMS

Hypsoblennius hentz, in the United States National Museum

43160 (1) and 43215 (5) — Chesapeake Bay, Cape Charles, Va.; W. P. Seal; Sept. 15–30, 1890.
46313 (1) — Corpus Christi, Texas; B. W. Evermann; Nov. 27–30, 1891.
51887 (2) — Beaufort, N. C.; B. A. Bean and C. A. McKnew; June 3–20, 1904.
51932 (1) — Beaufort, N. C.; E. W. Gudger and G. T. Bean; July and Aug., 1904.
59037 (3) — Off southern end of May River, S. C.; *Fish Hawk* Sta. 1651; 1891.
59062 (1) — Jericho Creek, S. C.; *Fish Hawk;* Jan. 23, 1891.
69741 (1) — Mouth of Hampton Creek, Hampton, Va.; M. C. Marsh; Feb. 24, 1898.
67918 (1) — Old Point Comfort, Va.; L. G. Harron; Sept., 1900.
67919 (2) — Little Bay, near Ocean View, Va.; L. G. Harron; Sept., 1898.
73199 (1) — Charleston, S. C.; *Fish Hawk;* date?
85095 (1) — Ft. Macon Beach, N. C.; W. J. Crozier and S. Hecht; July 3 (?), 1912.
91155 (1) — Cape Charles, Va.; W. C. Schroeder; Nov. 23, 1921.
91156 (1) — Ocean View, Va.; W. C. Schroeder; Sept. 26, 1922.
91157 (2) — James Fishery, Norfolk, Va.; W. C. Schroeder; Aug. 20, 1921.
91158 (3) — Crisfield, Va.; W. C. Schroeder; Sept. 14–19, 1921.
91159 (1) — Chesapeake Bay, near Thimble Shoal Light, Va.; *Fish Hawk* Sta. 8403; Jan. 16, 1916.
91160 (1) — Chesapeake Bay, near Cove Point, Md.; *Fish Hawk* Sta. 8078; March 21, 1914.
91161 (1) — Chesapeake Bay, near Hoopers Light, Md.; *Fish Hawk* Sta. 8026; Jan. 20, 1914.
91162 (1) — Chesapeake Bay, near Point No Point Light, Md.; *Fish Hawk* Sta. 8480; March 10, 1916.
91163 (1) — Chesapeake Bay, near Thimble Shoal Light, Va.; *Fish Hawk* Sta. 8497; April 21, 1916.
91457 (1) — St. Georges Sound, Fla.; E. Danglade; Jan., 1915.

Hypsoblennius hentz, in the Museum of Zoology, University of Michigan

102175 (1) — Off Champotón, Campeche, Mexico; E. P. Creaser and F. Castillo; July 13, 1932.
108023 (2) — Lemon Bay, Englewood, Fla.; Leonard Giovannoli, March 8, 1935.
110116 (1) — Lemon Bay, Charlotte Co., Fla.; Stewart Springer; Jan. 20, 1936.
111745 (1) — Oyster beds, vicinity of Rockport, Tex.; Albert Collier; Sept., 1935 — June, 1936.

Hypsoblennius ionthas, in the United States National Museum

26617 (1) — Cedar Keys, Fla.; Silas Stearns; 1880.
30850 (1) — Pensacola, Fla.; Jordan and Stearns (type of *I. scrutator*); date?
30856 (2) — Pensacola, Fla.; Jordan and Stearns (types of *I. ionthas*); date?
69350 (1) — Palacios Reef, Matagorda Bay, Tex.; T. E. B. Pope; Dec. 23, 1904.
69371 (1) — St. Simion Mills, Ga.; Rev. Watson Winn; Sept. 29, 1908.
73546 (1) and 73547 (1) — Mobile Bay, Ala.; W. F. Hill; 1894.
83969 (1) — West Indies; collector?; date? [data hardly to be trusted].
85499 (1) — Savannah, Ga.; collector?; date?
85705 (3) — Sawmill Creek, S. C., near lower mouth of Clambank Creek; Dec. 30, 1890
91454 (3) — Apalachicola, Fla.; E. Danglade; March 15, 1915.
92211 (1) — St. Vincent Sound, Fla.; E. Danglade; April 14, 1915.

Hypsoblennius ionthas, in the Museum of Zoology, University of Michigan

61446 and 61448 (18) — Pensacola, Fla.; Jordan and Evermann; 1886.
111744 (7) — Oyster beds in vicinity of Rockport, Tex.; Albert Collier; Sept., 1935 — June, 1936.
114469 (13) and 114475 (1) — Sand Point Reef, Lavaca Bay, Calhoun Co., Tex.; Gordon Gunter; Dec. 14, 21, 24, 1936.
——— (1) — Oyster bed in Matanzas River, about 1.5 miles south of Matanzas Inlet, Fla.; Carl L. Hubbs and family; Aug. 19, 1936.
——— (1) — Off Pass à Lutre, La.; Stewart Springer; Mar., 1931.

University of Michigan

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THE STATUS AND SYNONYMY OF *VERECUNDUM RASILE*, A FLOUNDER OF BRAZIL AND ARGENTINA

CARL L. HUBBS AND TOMÁS L. MARINI *

IN STUDYING a collection of marine fishes brought to the University of Michigan from Argentina by the junior author we found a species of flounder which in recent years has been referred to *Hippoglossina* and to *Xystreurys*. As the result of a kind suggestion by Dr. J. R. Norman, of the British Museum, it was determined that this flounder is the one described by Jordan in 1890 as *Verecundum rasile*. Inasmuch as this species differs trenchantly from the genotypes of *Hippoglossina*, *Xystreurys*, and other related genera *Verecundum* may be regarded as a valid genus.

The relationships of *Verecundum* lie with a group of "genera allied to *Paralichthys*," classified by Jordan and Evermann (1898 : 2606, group *dd* in Key) among the Hippoglossinae. Largely on the characters of the olfactory laminae and on the crossing of the optic nerves, discovered by Kyle and Parker respectively, Regan (1910 : 492) elevated this group to subfamily rank (Paralichthyinae). He classed this subfamily in the Bothidae, and added to it the other genera of that family having both pelvic fins short-based. Jordan (1923 : 168) listed these other genera in the Bothidae, and elevated the *Paralichthys* group to family rank, but Norman (1934) has followed Regan's treatment.

In confirmation of the classification adopted by Regan and Norman we have determined that the optic nerve of the right eye is dorsal in a sinistral specimen of *Hippoglossina stomata* (a species which in superficial characters closely resembles the Hippoglossinae of the Pleuronectidae) and in a dextral (reversed) example of *Xystreurys liolepis*. So far as we have tested the character, the olfactory laminae

* Chief of the fisheries service of Argentina. This paper was prepared while the junior author was studying in the United States under a Guggenheim fellowship.

are longitudinal and without rachis in every normally dextral genus, with the exception of *Atheresthes* (*stomias* and *evermanni*) and *Poecilopsetta* (*hawaiiensis*). In those genera the apparently primitive arrangement of the laminae, radiating outward and usually backward from a median longitudinal rachis, is maintained, although the optic nerve of the left side is dorsal.[1] Pleuronectid genera (or subgenera) found by us to have longitudinal olfactory laminae without rachis are: *Hippoglossus, Hippoglossoides, Lyopsetta, Eopsetta, Cleisthenes, Xystrias, Verasper* (this dextral genus was misplaced in the Paralichthyinae by Jordan and Evermann and by Regan), *Psettichthys, Clidoderma, Isopsetta, Parophrys, Lepidopsetta, Limandella, Pseudopleuronectes, Platichthys, Hypsopsetta, Pleuronichthys, Dexistes, Tanakius, Glyptocephalus,* and *Errex*. Despite some marked superficial resemblances it is obviously unnecessary to compare *Verecundum* with any of these genera.

We have seen the olfactory laminae arranged on either side of a median longitudinal rachis in *Verecundum* and in *Hippoglossina, Xystreurys, Paralichthys, Pseudorhombus, Tephrinectes,* and *Citharichthys*.

Verecundum Jordan

This genus may be defined as follows. The eyes are sinistral. The subsymmetrical mouth is of moderate size: the maxillary reaches to below the pupil. The jaws bear a single irregular series of rather small bluntly conical teeth, in some specimens becoming almost biserial anteriorly. The palate is toothless. The subsymmetrical pelvic fins, each of 6 rays, are separated from the anal. The pelvic fin of the eyed side slightly exceeds its mate in size and is located somewhat nearer to but hardly on the midventral line. The narrowly pointed pectoral fin of the eyed side is almost as long as the head; its second ray is almost or quite as long as the third, which is longer than the fourth; the main rays below the third ray are all branched on the outer third; the interradial membranes are normal. The broadly rounded pectoral fin of the blind side is somewhat more than half as long as the right pectoral; its rays are all unbranched. The dorsal fin begins above the front of the pupil, and has no definitely

[1] Other fundamentally dextral flounders retaining the radiating type of olfactory laminae have been discovered by Regan (1920 : 213) and also by Norman (1926 : 257), who has made use of some of our findings in his recent *Monograph of the Flatfishes* (1934 : 43).

exserted or elongated rays. The anal is similar, and without externally evident spine. Only a few (posteriormost) dorsal and anal rays are branched. There are about 80 dorsal and 65 anal rays. The caudal fin is longer than the head and is sharply pointed medially. The lateral line lacks an accessory branch, and rises anteriorly to form a low to moderate curve, having a height one fourth to one sixth of the chord. Most of the lateral line tubes have a conspicuous branch extending obliquely upward and backward, and some have a similar ventral branch. The scales are of moderate size (in about 80 oblique rows) and are strictly cycloid on both sides. Accessory scales are relatively few and inconspicuous. The gill rakers, in number about 5 + 10, are rather slender and pointed, and finely dentate on the inner surface and on the edge toward angle of arch. There are 6 branchiostegals. The rather large eyes lie on about the same vertical and are separated by a narrow sigmoid ridge. The upper eye is strictly lateral, but its upper ridge enters the dorsal profile. The chin recedes, with only a weak angle on the edge anteriorly. The olfactory laminae form two series of vertical flaps, perpendicularly arranged on either side of a median longitudinal rachis. The anterior nostril of the eyed side bears on its posterior edge a pointed flap, which reaches the front rim of the posterior nostril. The anterior nostril of the blind side bears a posterior flap which is very narrow and reaches to the hind edge of the posterior nostril. No flaps or cirri occur on or about the eyes. The body is moderately slender (depth about 2.3), and the caudal peduncle is very short (two fifths as long as deep).

Verecundum differs from *Hippoglossina* Steindachner (1876 : 61), to which Berg (1895 : 75) referred his *H. notata* (a synonym of *Verecundum rasile*), in having cycloid instead of ctenoid scales, a curve rather than an arch in the lateral line, the pectoral fin of the eyed side and caudal much more elongate, the caudal fin subsessile, and in other respects.

As is indicated in the following comparison, *Verecundum* differs in many characters from *Xystreurys* Jordan and Gilbert (1880 : 34), to which Regan, Ribeiro, and Norman referred the species under consideration.

TABLE I

COMPARISON OF *VERECUNDUM* WITH *XYSTREURYS*

	Verecundum (rasile)	*Xystreurys (liolepis)*
Body	Rather slender	Rather broad
Eyes	Sinistral	Sinistral or dextral
Teeth	Fine	Moderate
Pectoral, eyed side:		
Length	Somewhat shorter than head; less than twice as long as pectoral of blind side	Longer than head; more than twice as long as pectoral of blind side
Tip	Pointed	Rounded
Second ray	Nearly or quite equal to third	Much shorter than third
Third ray	Longer than fourth	Shorter than fourth
Membranes	Normal	Especially widened
Main rays	Those below third branched	All unbranched
Pectoral rays, blind side	Unbranched	Branched
Dorsal and anal rays branched	Posteriormost few only	Median and posterior rays
Caudal fin	Longer than head, sharply pointed	Much shorter than head, rounded
Lateral line with	Curve	Arch
Branch pores	Conspicuous	Inconspicuous
Scales	Moderate (about 80)	Small (about 120)
Accessory scales	Few, inconspicuous	Many, conspicuous
Gill rakers	Slender; dentate on inside and on edge toward angle of arch	Almost leaflike; obsolescently dentate, only on edge toward angle of arch
Flap of anterior nostril of blind side	Very narrow, shorter	Broader and longer
Olfactory laminae	Perpendicular to rachis, flaplike	Strongly oblique to rachis, hardly flaplike

Verecundum differs as follows from the commonly recognized American genera of Paralichthyinae with subsymmetrical pelvic fins, other than *Hippoglossina* and *Xystreurys:*

from *Thysanopsetta* in having the teeth uniserial or nearly so, the dorsal and anal rays scaled, and the dorsal fin beginning above instead of before the upper eye;

from *Lioglossina* in having the mouth smaller, the gill rakers longer and slenderer, no orbital flap on eye, the pectoral of eyed side much longer, and the lateral line with a curve instead of a broad arch;

from *Paralichthys* in having the mouth smaller, the scales cycloid,

the dorsal fin beginning above the eye, the lateral line less curved anteriorly, the teeth smaller, and the interorbital narrower;

from *Ramularia* in having the scales cycloid, the lateral line without real arch, the lateral line pores with only one branch or occasionally two branches, the body less deepened, the gill rakers much better developed, neither pelvic fin markedly produced, and the anterior dorsal rays not exserted;

from *Ancylopsetta* in having the scales cycloid, the body less deepened, the gill rakers much better developed, neither pelvic fin markedly produced, and the anterior dorsal rays not elevated;

from *Notosema* in having the scales cycloid, the anterior dorsal rays not produced, and the dorsal fin beginning above rather than before the upper eye;

and from *Gastropsetta* in having rather large and nonembedded scales, the dorsal beginning behind the front of the eye and without produced rays, neither pelvic fin elongated, and the gill rakers much better developed.

Other differences will no doubt be appreciated when *Verecundum* is carefully compared with any of these genera. It appears to be a fairly well marked genus.

The separation of *Verecundum* from *Xystreurys* is more than a matter of splitting or lumping. To classify *Verecundum rasile* of Atlantic South America in the same genus as the Californian *Xystreurys liolepis* would be to indicate that *V. rasile* is more closely related to *X. liolepis* than to several subtropical genera (or subgenera), particularly the Atlantic *Notosema* and *Ancylopsetta*. Such differentially close relationship between *rasile* and *liolepis* does not appear to be indicated, and there is no other evidence of definitive relationship between the fishes of California and those of southeastern South America.

Verecundum rasile Jordan

(Plate I)

Verecundum rasile. — Jordan, 1890 : 330.
Xystreurys rasile. — Norman, 1934 : 121, fig. 77; 1937 : 135, fig. 76.
Hippoglossina notata. — Berg, 1895 : 75.
Xystreurys notatus. — Ribeiro, 1903 : 192; 1915 : 11.
Xystreurys brasiliensis. — Regan, 1914a : 17; .1914b : 23, pl. 10, fig. 1.

Possibly more than one species or subspecies of *Verecundum* is represented in this synonymy, but the available information is insufficient for their separation.

The type specimen of *Verecundum rasile*, a long-forgotten species from Bahia, Brazil, which we have examined at the suggestion of Dr. J. R. Norman, agrees very well with the type description of *Hippoglossina notata* Berg and with our topotype of *H. notata* from Mar del Plata. The teeth in the type are somewhat more irregularly arranged than in our specimen, becoming almost biserial at front of jaws instead of remaining almost strictly uniserial throughout. The pectoral of the eyed side is about eight tenths instead of seven tenths as long as head, and its second ray is as long as, instead of a little shorter than the third ray. The type has 87 dorsal and 69 anal rays; 94 scales in lateral line, and about 83 oblique scale rows; 5 + 11 gill rakers; depth 2.25.

Ribeiro's description of "*Xystreurys notatus*" from Brazil indicates the eye as larger and the pectoral as somewhat shorter than in our example.

Regan's description and figure of *Xystreurys brasiliensis* also indicate the eye as larger than in our specimen, but the pectoral fin as longer. In response to our request Dr. J. R. Norman has reexamined the holotype of *brasiliensis*, 170 mm. long, and finds the left pectoral (possibly a little broken at the tip) seven eighths as long as head; eye 3.4 in head; orbit 3.0 in head; caudal peduncle 14 mm. deep and 6.5 mm. long as measured between caudal base and vertical from end of anal base. In the 98 mm. paratype he measures the pectoral 1.2 in head, the eye nearly 3.0, the orbit 2.6. In our specimen, about 228 mm. long over all, the left pectoral is seven tenths as long as head, the eye enters the head 3.8 times, the orbit 3.2 times; the comparable caudal peduncle measurements are 19 and 8 mm. The larger eye in the types of "*brasiliensis*" is probably due to age variation, for we find a graded series:

	Total length, mm.	*Eye in head*	*Orbit in head*
Paratype of *X. brasiliensis*	98	nearly 3.0	2.6
Holotype of *X. brasiliensis*	170	3.4	3.0
Topotype of *H. notata*	228	3.8	3.2

Our specimen shows the following additional characters: depth 2.35; depth of caudal peduncle 2.2 in head; head 4.2; upper jaw 2.5; highest dorsal ray, near middle of fin, 1.9 in head; highest anal ray 2.0; median caudal ray 3.5 in standard length; dorsal rays 84; anal rays 64; pectoral rays on each side 10; scales in lateral line

about 94; transverse scale rows above lateral line about 82; gill rakers 3 + 10 on eyed side and 5 + 10 on blind side.

Xystreurys ribeiroi Fowler and Bean (1923 : 26), of which we have also examined the type in the United States National Museum, is not closely related to the species under consideration, but it is referable to the genus *Paralichthys*. Norman (1934 : 72, fig. 38a) has referred this nominal species to the synonymy of *Paralichthys orbignyana*.

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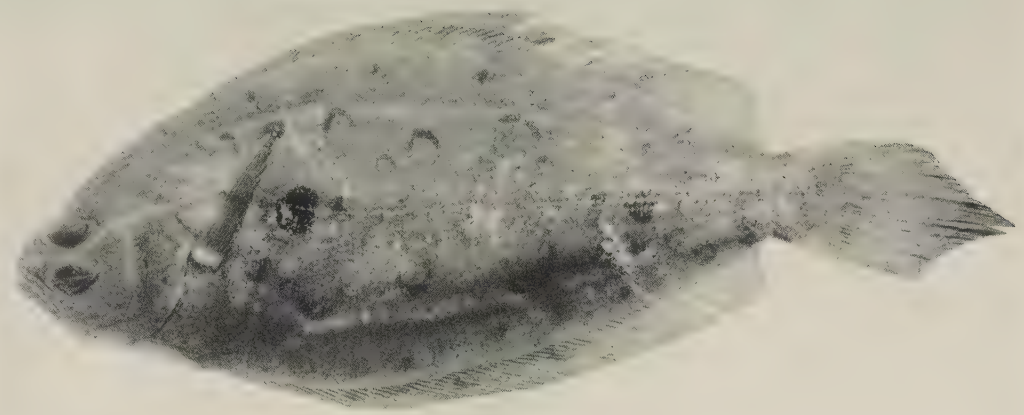

Verecundum rasile Jordan, from Mar del Plata. Standard length of specimen 177 mm. A topotype of *Hypoglossina notata* Berg. Photograph by F. W. Ouradnik

THE TAXONOMY AND DISTRIBUTION OF MICHIGAN BOMBIDAE, WITH KEYS*

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LATREILLE erected the genus *Bombus* in 1802, but in doing so he made no distinction between true bumblebees and their guests, the inquiline bumblebees. Shortly afterward Kirby noted that some females of the genus *Bombus* possessed corbiculae and that others lacked these structures. Illiger in 1806, using the same morphological character that had been observed by Kirby, indicated a distinct grouping of the two kinds of females, but he did not propose a name for the new division of *Bombus*. In 1832 Lepeletier proposed *Psithyrus* as the first generic name for the inquiline bumblebees or those without corbiculae.

Robertson (1903) placed the two genera in one subfamily, Bombinae, and at the same time proposed *Bombias* as an additional genus based on size of the eyes and their position with respect to the supraorbital line, and on the relative lengths of the malar space.

Franklin (1913), patterning his work after several European authorities, attempted to divide the genera of Bombidae into natural groups to indicate the relationships of the species. These groups, which were not designated as subgenera, were based primarily upon similarity of genitalia and shape of the middle tarsus. Each took the name of a typical species, i.e. the group of *fraternus* had as its type *B. fraternus*. In his paper Franklin either reported or predicted the occurrence of species in Michigan which represented eight of these groups within the two genera, *Bombus* and *Psithyrus*.

The tendency in recent publications has been to divide *Bombus* and *Psithyrus* into several subgenera, each of which represents a natural complex. Krüger (1920) and Frison (1927) have classified the natural complexes (subgenera of *Bombus*) under sectional names which are ranked midway between the genus and the subgenera they

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include. Krüger proposed the sections *Odontobombus* and *Anodontobombus*, and Frison created the section *Boopobombus* in order to include the subgenera that belong to *Bombias* of Robertson. These sectional names are employed primarily to show the phylogenetic lines of descent within the genus. Thus the classifications of Radoszkowski (1884), Vogt (1911), Franklin (1913), Krüger (1920), Plath (1927), and Frison (1927) reveal the trend toward a natural grouping which embodies the use of morphological differences and similarity of habits or biological relationships. For convenience here, however, the generic divisions have been limited to *Bombus* and *Psithyrus*.

Until recently a few workers have used Bremidae as the family name for the bumblebees. The International Commission on Zoölogical Nomenclature has ruled out the "Erlangen List of 1801"; consequently, *Bombus* is the oldest valid generic name and Bombidae the family name.

Color Variations within the Species

Superficially Bombidae exhibit numerous variations in color of pubescence. Among the suggested reasons for such variations the one which concerns the relation of altitude or the corresponding differences in latitude to the expression of color has been best substantiated, since some of the most brillantly colored bees are found at high altitudes. The significance of color variants, however, is questionable because gradations from the typical species to its variety are frequently encountered. A striking example of gradations is invariably found in *rufocinctus* and varieties, where diversified color patterns make difficult their correct keying. The recognition in recent publications of several new varieties which remain constant is a decided aid to identification of those species which show a wide range of variation.

Taxonomy

One has little trouble in recognizing at a glance the females of the two genera, but to tell the males apart is difficult. The superficial characters given to distinguish the males of *Bombus* and *Psithyrus* are often weak; only after the examination of numerous specimens can one readily see the differences between them. In general, *Psithyrus* males appear rougher and shaggier than *Bombus* males because the pubescence is sparser and the head of a *Psithyrus* male is blunter.

Never, in review of past works on the group or by examination of specimens, has the writer discovered any means of distinguishing between workers and queens other than size. Sometimes the larger workers are mistaken for small queens. Even though there may be a variation in size, females of *Psithyrus* are not designated as queens and workers, but simply as females.

If the antennae of a specimen are broken off or the tergites are obscured the sex can be determined with reasonable accuracy by noting the difference in appearance of the bifid tarsal claws. The inner tooth of the claw of a female is at most scarcely one half of the length of the outer tooth and is divergent; that of the male is always at least three fourths of the length of the outer tooth or equal or subequal to it, and shows little tendency to diverge. This character was first published by Cresson (1863, p. 84) with reference to *Bombus*, but it can be applied to specimens of *Psithyrus* as well.

Several terms in frequent use in the keys are defined or explained as follows:

Occiput, the area extending from the back of the neck up and over the top of the head to the supraorbital line.
Face, the area extending from a line midway between the supraorbital and the supra-antennal lines to the top of the clypeus (the supra-antennal line is an imaginary line tangent to the antennal bases, dorsally).
Supraorbital line, an imaginary line tangent to the caudal margins of the compound eyes.
Malar space, the area between the lower margins of the compound eye and the articulation points of the mandible. Its apical width is the distance between the two articulation points; its length is the distance from the lower margin of the eye to the mandible.
Disc, the dorsal area of the thorax between the wing bases.
Squama, the distal plate of the "outside clasper" of the male genitalia.
Volsella, one of a pair of narrow linear "inner claspers" of the male genitalia.
Tergite, the dorsal area of any abdominal segment unless otherwise specified.
Ferruginous, a rusty red brown.
Rufous, a brilliant to a deep red.

KEY TO THE GENERA OF BOMBIDAE

1. Antennae 12-segmented; six visible abdominal tergites; mandibles unbearded (females) 2
1. Antennae 13-segmented; seven visible abdominal tergites; mandibles bearded (males) 3

2. Outer surfaces of hind tibiae concave or flat, smooth, and hairless *Bombus*
2. Outer surfaces of hind tibiae convex, hairy ..... *Psithyrus*

3. Outer surfaces of hind tibiae with sparse and rather uneven distribution of hair; anterior margin of labrum incurved (volsellae and squamae corneous) ..... *Bombus*
3. Outer surfaces of hind tibiae rather densely and evenly covered with hairs; anterior margin of labrum outcurved (volsellae and squamae membranous) ..... *Psithyrus*

KEYS FOR SEPARATING THE SPECIES AND VARIETIES OF THE GENUS *BOMBUS*

QUEENS

1. Mesonotum with no distinct interalar black band; disc often nude and surrounded with considerable black (specimens of *B. rufocinctus* may show this weakly extended to wing bases) 2
1. Mesonotum with distinct interalar black band, or at least with indistinct band which reaches wing bases 10

2. First tergite yellow; remainder of abdomen without yellow .... *impatiens*
2. First tergite entirely yellow; second with basal middle yellow or rusty yellow; remainder of abdomen entirely black 3
2. First and second tergites largely yellow 4

3. Basal median half of second tergite rusty; occiput black; ocelli well below supraorbital line ..... *separatus*
3. Basal median half of second tergite yellow; occiput largely yellow; ocelli very near supraorbital line ..... *bimaculatus*

4. Yellow of pleura not extending to leg bases; first and second tergites and sometimes apical margin of fifth largely yellow; remainder black; malar space not longer than its apical width ..... *perplexus*
4. Yellow of pleura extending to leg bases 5

5. First to fourth tergites (inclusive) entirely yellow; remainder black; occiput and face black; malar space longer than its apical width *fervidus* var. *dorsalis*
5. Not as above 6

6. Malar space always noticeably longer than its apical width, giving the head a long appearance; ocelli very near supraorbital line; pubescence shaggy; first and second tergites yellow; remaining tergites black; occiput usually with a dominant triangular patch of yellow ..... *vagans*
6. As above, except that fifth tergite has yellow pubescence *vagans* var. *helenae*
6. Malar space not longer than wide 7

7. First and second tergites yellow, second usually apically indented at the middle; face and occiput dominantly black; head wide ..... *affinis*
7. Not as above 8

8. Ocelli small, on supraorbital line; thoracic pubescence fine; first and second tergites entirely yellow; often a trace of yellow on fifth and sixth tergites; malar space about as long as its apical width, but head rounded; fourth and fifth antennal segments not equal; mesal margin of the mandible with decided notch; small (12–15 mm.) *frigidus* var. *sandersoni*

8. Ocelli large and below supraorbital line; malar space always shorter than its apical width; fourth and fifth antennal segments equal or subequal 9

9. First tergite tawny yellow; second and third with rufous hairs; remainder of abdomen tawny yellow except apex, which appears black (somewhat variable) ..... *rufocinctus*

9. First tergite tawny yellow; second usually tawny at base, black at sides and ferruginous at apex; third with ferruginous pubescence; fourth and fifth usually largely tawny yellow (variable) *rufocinctus* var. *iridis*

9. First tergite yellow; second yellow but frequently black at sides; fourth and fifth often with yellow sparsely intermixed with black at sides; remainder of abdomen black but sometimes variable *rufocinctus* var. *albertensis*

9. Not as above 17

10. First to fourth tergites (inclusive) entirely yellow; occasionally second and third display a pale red cast, but not rufous 11

10. First to fourth tergites not as above 13

11. Occiput yellow, face with whitish pubescence; large median area of clypeus bare; smooth and glossy; malar space longer than its apical width; pleura largely black; yellow of thorax and abdomen tawny *borealis*

11. Occiput and face largely black or not as above 12

12. Interalar black band rather narrow; malar space longer than its apical width; head elongate ..... *fervidus*

12. Interalar band rather wide, its posterior margin forming a distinct V on the scutellum; malar space slightly shorter than its apical width; head rounded ..... *ternarius* var. *expallidus*

13. Pleura black, the yellow pubescence of thorax extending ventrally but a short distance anterior to wing bases 14

13. Pleura covered with yellow pubescence to leg bases or nearly so 15

14. Ocelli large and placed well below supraorbital line; occiput with considerable yellow; first tergite usually black; second and third entirely yellow; remainder of abdomen black ..... *auricomus*

14. Ocelli placed near supraorbital line; occiput black; first and fourth tergites black; second and third yellow; fifth and sixth black except yellow at apices ..... *terricola*

14. Ocelli placed near supraorbital line; occiput black; first (usually largely), second, and third tergites yellow; remainder of abdomen black *americanorum*

15. Ocelli small, near supraorbital line; first and second tergites yellow and also apices of fifth and sixth; interalar band narrow; small (13–15 mm.) ..... *frigidus* var. *couperi*

15. Ocelli large and noticeably below supraorbital line, or not as above 16

16. First and second tergites entirely yellow; occiput and face dominantly black; large (20–28 mm.) ..... *fraternus*

16. Not as above 17

17. First tergite tawny yellow; second with at least the basal middle tawny; fourth and fifth usually largely tawny yellow; occiput and face mostly

yellow; malar space never as long as apical width; medium (14–16 mm.) ..... *rufocinctus* var. *prunellae*

17. First and fourth tergites yellow; second and third with rufous pubescence; remainder of abdomen black; wide interalar band with its posterior margin forming a V on the scutellum; occiput and face usually with some black; medium (14–17 mm.) ..... *ternarius*

WORKERS

1. Mesonotum yellow with no distinct interalar black band; disc frequently nude and encircled with a few black hairs (except occasional small specimens, 7–14 mm., that show most of the abdominal yellow on first and second tergites; malar space short; use 7) 2
1. Mesonotum with a distinct black band, or at least with a black band intermixed with yellow 7

2. First tergite entirely yellow; remainder of abdomen black .... *impatiens*
2. First tergite entirely yellow; second with basal middle yellow or rusty; remainder of abdomen black 3
2. Not as above 4

3. Basal median half of second tergite rusty; occiput dominantly black *separatus*
3. Basal median half of second tergite yellow; occiput largely yellow *bimaculatus*

4. Yellow pubescence of pleura not extending to leg bases; sometimes a whitish, but not yellow, pubescence extends well down on pleura; third tergite may show considerable yellow; malar space not longer than its apical width ..... *perplexus*
4. Yellow pubescence of pleura extending to leg bases 5

5. First to fourth tergites (inclusive) entirely yellow; occiput and face black; malar space longer than its apical width ... *fervidus* var. *dorsalis*
5. Not as above 6

6. First and second tergites yellow and often a trace of yellow on fifth and sixth tergites; malar space no longer than its apical width; mesal margin of mandible with a decided notch; head rounded *frigidus* var. *sandersoni*
6. First and second tergites yellow; remainder of abdomen black except sometimes yellow at extreme sides beyond second segment; malar space longer than its apical width; head elongate ..... *vagans*
6. First and second tergites yellow; fifth with yellow pubescence; remaining tergites sometimes with yellow at extreme sides but usually black; malar space longer than wide; head elongate ..... *vagans* var. *helenae*

7. First to fourth tergites (inclusive) entirely yellow; occasionally second and third display a pale red cast, but not rufous 8
7. First to fourth tergites not as above 10

8. Occiput yellow, face with whitish pubescence; median area of clypeus bare and glossy; pleura largely black; yellow of thorax and abdomen tawny ..... *borealis*
8. Occiput and face largely black or not as above 9

9. Interalar black band rather narrow; malar space longer than apical width ..... *fervidus*
9. Interalar band rather wide, its posterior margin forming a distinct V on the scutellum; malar space about as long as its apical width *ternarius* var. *expallidus*

10. Pleura largely black; the yellow extending ventrally only a short distance 11
10. Pleura largely yellow 12

11. Ocelli large and placed well below supraorbital line; occiput with considerable yellow; first tergite largely black, except considerable yellow sometimes at sides; second and third yellow; remainder of abdomen black ..... *auricomus*
11. Ocelli placed near supraorbital line; occiput black; first and fourth tergites black; second and third yellow; fifth and sixth black except yellow at apices; scutellum largely black ..... *terricola*
11. Ocelli placed near supraorbital line; occiput black; first three tergites yellow, except that first may be yellow intermixed with black; remainder of abdomen black ..... *americanorum*

12. First and second tergites entirely yellow; remainder of abdomen black; ocelli well below supraorbital line; pubescence fine, short, and compact; malar space less than one half of its apical width ..... *fraternus*
12. First, second, and fifth tergites and frequently apex of fourth yellow; remainder of abdomen black except that sixth tergite is often yellow intermixed with black; interalar band covering most of mesonotum; malar space as long as its apical width ..... *frigidus* var. *couperi*
12. Not as above 13

13. First tergite entirely yellow; second ferruginous except yellow at sides and apex; remainder of abdomen entirely black; occiput and face black or having only a few yellow hairs ..... *affinis*
13. First and second tergites as above; fourth tergite largely covered with ferruginous pubescence except sides; remainder black, or ferruginous pubescence covering fourth entirely (some admixture of black) and extending anteriorly on the apex of third or posteriorly over greater part of fifth tergite; occiput and face black ..... *affinis* var. *novae-angliae*
13. Not as above 14

14. Interalar black band wide and distinct, its posterior margin forming a well-defined V on scutellum; ocelli either on or just above supraorbital line; occiput and face usually dominantly black; first tergite yellow; second and third rufous; fourth rufous and yellow but usually all yellow; fifth and sixth black ..... *ternarius*
14. Not as above 15

15. First tergite yellow; second largely so, with rufous pubescence at sides and apex; third and fourth rufous, sometimes sparse yellow on apex of fourth; fifth and sixth largely black; malar space shorter than its apical width ..... *rufocinctus*
15. First tergite yellow; second largely yellow except at sides (black) and apex (ferruginous); third and fourth largely ferruginous, sometimes bearing much black; malar space shorter than its apical width *rufocinctus* var. *iridis*

15. Abdominal pattern varying from that above; fourth tergite largely black 16

16. First tergite yellow; second yellow at base or yellow covering most of tergite; remainder of abdomen largely black but frequently some ferruginous hairs on apex of third and fewer on fourth; malar space shorter than its apical width ..... *rufocinctus* var. *albertensis*
16. First and second tergites largely tawny yellow; fourth and fifth with considerable tawny yellow; remainder of abdomen largely black; malar space shorter than its apical width .... *rufocinctus* var. *prunellae*

MALES

1. Eyes large and bulging; ocelli well below supraorbital line; lateral ones nearer the compound eyes than to each other 2
1. Eyes not bulging; ocelli near or on supraorbital line 7

2. First tergite entirely yellow; basal middle area of second rusty; remainder of abdomen black; third antennal segment shorter than fourth and fifth segments together ..... *separatus*
2. Not as above 3

3. First and second tergites entirely yellow; remainder of abdomen black; large (13–22 mm.) ..... *fraternus*
3. First three tergites yellow; remainder of abdomen black; large (16–19 mm.) ..... *auricomus*
3. Not as above; small to medium (10–15 mm.) 4

4. Third and fourth tergites dominantly black; remainder of abdomen variable; considerable black pubescence on head 5
4. Third and fourth tergites either dominantly rufous or tawny yellow and ferruginous; considerable yellow pubescence on head 6

5. Third, fourth, and seventh tergites dominantly black, although each may show a sparse apical fringe of tawny yellow; remaining tergites largely tawny yellow ..... *rufocinctus* var. *prunellae*
5. First and second tergites largely tawny yellow, remainder of abdomen black, although often third and fourth tergites bear an admixture of ferruginous hairs at apices ..... *rufocinctus* var. *albertensis*

6. Apex of second tergite, entire third and fourth tergites, and frequently base of fifth covered with rufous pubescence; remainder of abdomen largely yellow ..... *rufocinctus*
6. Entire abdomen covered with tawny pubescence, but frequently an intermixture of ferruginous hairs on third and fourth tergites; pubescence of head largely yellow ..... *rufocinctus* var. *iridis*

7. First or first and second tergites entirely yellow, or first and basal middle of second yellow; remainder of abdomen black except often some yellow on apical segments 8
7. Not as above 11

8. First tergite yellow; remainder of abdomen black ..... *impatiens*
8. First tergite yellow; second with yellow only at basal middle; remaining tergites black ..... *bimaculatus*
8. First and second tergites entirely yellow 9

9. Malar space distinctly longer than its apical width; face long; flagellar segments between distal and third segments not noticeably enlarged; pubescence shaggy; sometimes sides of tergites beyond second show yellow ..... *vagans*
9. As above, but yellow pubescence on some or all of last three tergites ..... *vagans* var. *helenae*
9. Malar space only about as long as wide; face rounded; flagellar segments enlarged between distal and third segments 10

10. Rather distinct interalar black band present; often fifth and sixth tergites with considerable yellow on apices; clypeus densely covered with whitish yellow pubescence ..... *frigidus* var. *couperi*
10. No interalar band present and rarely any black hairs on disc; tergites three to seven dominantly black ..... *frigidus* var. *sandersoni*

11. First tergite black; second and third yellow and sometimes sparse yellow on fourth; tawny yellow on apices of sixth and seventh; remainder of abdomen black ..... *terricola*
11. Not as above 12

12. Mesonotum without a distinct interalar black band 13
12. Mesonotum with a distinct interalar band or a band intermixed with yellow 15

13. First to fifth tergites (inclusive) yellow; occiput and face usually black; third antennal segment shorter than fifth; face long ..... *fervidus* var. *dorsalis*
13. First three tergites largely yellow; or entire abdomen may be more or less covered with yellow; third antennal segment as long as fifth; occiput and face yellow ..... *perplexus*
13. Not as above 14

14. First tergite yellow; second ferruginous except sides and apex, which are yellow; remainder of abdomen black ..... *affinis*
14. First two tergites as above; amount of ferruginous pubescence on remaining tergites variable, but usually on fourth and fifth; sometimes tergites three to six are largely ferruginous with their sides black; seventh tergite black ..... *affinis* var. *novae-angliae*

15. Occiput yellow; face and clypeus usually with much yellow or whitish pubescence 16
15. Occiput and face largely black 18

16. Second and third tergites rufous; sixth and seventh black; remainder of abdomen yellow; interalar band rather wide and forms a V on the scutellum; small (10–13 mm.) ..... *ternarius*
16. Not as above; first four tergites yellow; occasionally second and third display a pale red cast, but not rufous 17

17. Pleura largely black; median area of clypeus bare and smooth ... *borealis*
17. Pleura largely yellow; clypeus covered with yellow pubescence ..... *ternarius* var. *expallidus*

18. Interalar black band narrow but distinct; first to fifth tergites (inclusive) lemon-yellow; sixth (usually) and seventh black; scutellum without numerous black hairs; pleura always largely yellow; medium (18–24 mm.) ..... *fervidus*

18. Interalar band not well defined or intermixed with much yellow; scutellum frequently largely black; first four tergites dull yellow; remainder of abdomen any combination of yellow and ferruginous or black; pleura frequently largely black; large (22–30 mm.) ..... *americanorum*

KEYS FOR SEPARATING THE SPECIES AND VARIETIES OF THE GENUS *PSITHYRUS*

FEMALES

1. Occiput largely black; yellow pubescence of pleura not extending to leg bases; fourth tergite and frequently apical sides of third and sides of fifth tawny yellow; remainder dark ..... *ashtoni*
1. Occiput largely yellow 2
2. Third tergite largely black except at extreme sides; remainder of abdomen dark; mesonotum with little or no black pubescence . *laboriosus*
2. Third tergite largely yellow, but yellow may occur also on extreme posterior corners of first or second; remainder dark; mesonotum with little or no black pubescence ..... *laboriosus* var. *citrinus*
2. Not as above; usually considerable black pubescence on mesonotum or a rather distinct interalar black band 3
3. Fourth tergite largely yellow; frequently yellow occurring on sides of first and third; remainder of abdomen most often dark; basal tubercles of labrum not prominent and angular toward the median line. *fernaldae*
3. First tergite frequently sparsely clothed with yellow; second and third usually with considerable yellow at sides and apices; fourth and fifth frequently with yellow at sides, but at least dark at centers; basal tubercles of labrum prominent, angular toward median line ... *insularis*

MALES

1. Yellow pubescence of pleura extending to leg bases 2
1. Yellow pubescence of pleura not extending to leg bases ..... *ashtoni*
2. First two tergites entirely yellow and often basal sides of third; sometimes basal part of second bearing dark pubescence; remainder of abdomen dark ..... *laboriosus*
2. First three tergites largely yellow and frequently anterior corners of fourth ..... *laboriosus* var. *citrinus*
2. Not as above 3
3. First and third tergites yellow; second yellow, except frequently black at basal sides; remaining tergites except seventh usually bearing considerable yellow at sides; interalar black band present ..... *insularis*
3. First tergite entirely yellow; second and third (variable) may be largely yellow or black, but fourth is always yellow; fifth, sixth, and seventh dominantly black; interalar band indistinct ..... *fernaldae*

Annotated List of Species and Varieties

The conclusions regarding the distribution of each species and variety in Michigan are based upon records from several private col-

lections; from the collection of Michigan State College; from the collection of the Museum of Zoology, University of Michigan; from several publications; and from numerous records supplied by Dr. T. H. Frison.

The life zones of C. Hart Merriam (*U. S. D. A., Biol. Surv. Bull. 10,* 1898) were followed in associating a species with one or more of the Boreal, Transition, or Upper Austral zones.

Bombus auricomus (Robt.). — Occurs in the counties of the Upper Austral and Transition zones, having been recorded from Bay, Berrien, Ingham, Eaton, Huron, Kent, Livingston, Macomb, Midland, Oakland, Washtenaw, and Wayne counties. Fairly common.

Bombus separatus Cress. — Occurs commonly in the Upper Austral and Transition zones: Mason, Lake, Osceola, Clare, Oceana, Isabella, Midland, Bay, Huron, Montcalm, Saginaw, Lapeer, Shiawassee, Kent, Allegan, Barry, Ingham, Livingston, Oakland, Kalamazoo, Jackson, Washtenaw, Wayne, Berrien, and Monroe counties. Scattered records from the Boreal Zone are Chippewa, Mackinac, Emmet, Cheboygan, Charlevoix, Grand Traverse, Wexford, Oscoda, Iosco, and Ogemaw counties.

Bombus rufocinctus Cress. — Distribution apparently confines itself almost entirely to the Boreal and Transition zones, but specimens have been taken as far south as Washtenaw County. Other records are Chippewa, Menominee, Cheboygan, Alpena, Clare, Midland, Huron, Lapeer, and Oakland counties. Not common.

Bombus rufocinctus var. iridis Ckll. & Porter. — Distribution similar to that of the typical species, except that it has never been reported very deep in the Transition Zone. Recorded from Chippewa, Mackinac, Cheboygan, Grand Traverse, Gladwin, Midland, and Huron counties. Rare.

Bombus rufocinctus var. prunellae Ckll. & Porter. — Recorded from but four counties: Cheboygan, Alpena, Midland, and Huron. Apparently it follows the same distribution as that of the typical species, but is rare.

Bombus rufocinctus var. albertensis Ckll. — The most abundant variety of *rufocinctus* in Michigan, being recorded largely from the Transition Zone, although it should likewise occur in the Boreal. Records have come from Luce, Gogebic, Emmet, Charle-

voix, Grand Traverse, Missaukee, Mason, Osceola, Midland, Bay, Huron, Gratiot, Shiawassee, Lapeer, Ingham, Livingston, Oakland, Jackson, and Washtenaw counties. Not common.

Bombus borealis Kby. — Range largely in the Boreal Zone, but specimens have been taken in two counties in the southeastern part of the state: Oakland and Jackson. Other county records are: Alger, Menominee, Chippewa, Mackinac, Alpena, Grand Traverse, Wexford, Midland, Bay, and Huron. An uncommon species throughout the state.

Bombus fervidus Fab. — Widely distributed in the state, as shown by the following county records: Alger, Chippewa, Mackinac, Cheboygan, Charlevoix, Otsego, Alpena, Grand Traverse, Alcona, Iosco, Mason, Lake, Clare, Gladwin, Midland, Bay, Huron, Montcalm, Ottawa, Lapeer, Kent, Eaton, Ingham, Livingston, Oakland, Macomb, Washtenaw, Berrien, St. Joseph, and Branch. Common.

Bombus fervidus var. dorsalis Cress. — Variety probably of the same distribution as that of the typical species, but has been taken in only two counties: Oceana and Ingham. Uncommon.

Bombus americanorum (Fab.) (= pennsylvanicus DeG.). — Common to the Upper Austral and ranges into the Transition Zone. Records from Berrien, St. Joseph, Branch, Monroe, Kalamazoo, Jackson, Washtenaw, Macomb, Oakland, Livingston, Ingham, Barry, Kent, Shiawassee, Lapeer, Huron, Midland, Oceana, and Mason counties. It has been recorded in two counties of the Boreal Zone, Alpena and Alger, but its occurrence in Alger County is questionable because the species is fairly common only over the lower half of Michigan.

Bombus terricola Kby. — Widely distributed in the Boreal Zone, occurring somewhat in the Transition Zone, and recorded in but two counties of the Upper Austral: Jackson and Mason. It has been taken in all the counties of the Upper Peninsula, and in Emmet, Cheboygan, Charlevoix, Antrim, Otsego, Alpena, Grand Traverse, Oscoda, Iosco, Ogemaw, Roscommon, Mason, Lake, Gladwin, Isabella, Midland, Bay, Huron, Shiawassee, and Ingham counties. The species belongs to the Canadian fauna and is common in the northern part of Michigan.

Bombus affinis Cress. — Recorded mostly from the Transition Zone, although it has occurred in the Upper Austral in both Jackson

and Washtenaw counties. Other records are: Benzie, Manistee, Isabella, Midland, Gratiot, Lapeer, Kent, Ingham, Livingston, and Oakland counties. Apparently it does not occur in the Boreal Zone and is not a common species.

BOMBUS AFFINIS var. NOVAE-ANGLIAE Beq. — Probably confined to the Upper Austral and Transition zones, as is the typical species. Recorded from two counties only: Washtenaw and Ingham. Known in only the male and worker phases. Rare.

BOMBUS BIMACULATUS Cress. — Widely distributed in the three zones of the Lower Peninsula and recorded from Mackinac County in the Upper Peninsula. The county records of the Lower Peninsula are: Cheboygan, Oscoda, Grand Traverse, Manistee, Missaukee, Roscommon, Mason, Midland, Huron, Shiawassee, Kent, Allegan, and Jackson. Relatively uncommon.

BOMBUS IMPATIENS Cress. — Associated with the Upper Austral and Transition zones, but has been taken in the Boreal Zone in Emmet, Cheboygan, and Grand Traverse counties, out of its ordinary range, where it is rare. Other records are: Mason, Bay, Midland, Huron, Oceana, Ottawa, Lapeer, St. Clair, Allegan, Kent, Ingham, Livingston, Oakland, Macomb, Kalamazoo, Jackson, Washtenaw, Wayne, Berrien, St. Joseph, and Branch counties. Common in the southern part of Michigan.

BOMBUS TERNARIUS Say. — Occurs widely over the Boreal Zone and extends into the Transition; recorded in one county of the Upper Austral — Mason. Taken in all counties of the Upper Peninsula except Houghton. Other Boreal county records are: Emmet, Charlevoix, Cheboygan, Presque Isle, Alpena, Otsego, Benzie, Kalkaska, Oscoda, and Iosco. Also recorded from Huron, Shiawassee, and Oakland in the Transition Zone. Fairly common in northern Michigan.

BOMBUS TERNARIUS var. EXPALLIDUS Ckll. — All records of this variety from the Boreal Zone: Luce, Chippewa, Mackinac, and Emmet counties. Rare.

BOMBUS FRIGIDUS var. COUPERI Cress. — Recorded to date only from the Upper Peninsula (Boreal Zone) in three counties: Keweenaw (Isle Royale), Chippewa, and Mackinac. It probably occurs to some extent over all the counties of the Upper Peninsula and the northernmost of the Lower Peninsula. Not common, except in extreme northern Michigan.

Bombus frigidus var. sandersoni Fkln. — Variety recorded from Alger County (one queen) and from Ingham County (one queen and one worker). Since its appearance is almost identical with that of typical *vagans*, it is most likely to be misidentified. Probably occurs in all three zones, but is not common.

Bombus perplexus Cress. — Apparently occurring in all three zones, but most records are within the Boreal Zone: Keweenaw, Gogebic, Iron, Marquette, Alger, Luce, Chippewa, Mackinac, Emmet, Charlevoix, Cheboygan, Leelanau, Oscoda, Alcona, Mason, Huron, Oakland, Washtenaw, and Jackson counties. Not common.

Bombus vagans F. Sm. — One of the most widely distributed species in the state, occurring in all three zones. The following records indicate its common occurrence: Keweenaw, Gogebic, Marquette, Dickinson, Menominee, Alger, Schoolcraft, Luce, Mackinac, Chippewa, Emmet, Cheboygan, Charlevoix, Alpena, Benzie, Oscoda, Roscommon, Ogemaw, Iosco, Mason, Osceola, Clare, Bay, Midland, Isabella, Huron, Montcalm, Lapeer, Macomb, Oakland, Livingston, Ingham, Kent, Kalamazoo, Jackson, Washtenaw, Berrien, St. Joseph, and Branch counties.

Bombus vagans var. helenae Frison. — Variety occurring in the same nest with the typical species, *vagans*, and therefore following the same range of distribution. Not common.

Bombus fraternus (F. Sm.). — Included among species found in Michigan on the authority of Doctor Franklin (1913), who says it occurs in southern Michigan (*Trans. Am. Entomol. Soc.*, 38 : 424), and Doctor Frison (personal communication). Among the records examined the writer has seen none indicating the distribution of this species in Michigan. If it does occur in the state, the species must be rare and confined to the southernmost counties.

Psithyrus ashtoni (Cress.). — Recorded by Plath (1934) as a social parasite of *B. affinis* and *B. terricola;* principally recorded from the Boreal Zone, which leads the writer to believe it is a guest of *B. terricola* in Michigan. Taken in Keweenaw, Gogebic, Iron, Marquette, Dickinson, Menominee, Alger, Schoolcraft, Chippewa, Mackinac, Emmet, Cheboygan, Charlevoix, Alpena, Grand Traverse, Roscommon, Ogemaw, Iosco, Mason, Midland, Huron, and Oakland counties. Most widely distributed and probably the most common species of *Psithyrus* in this state.

PSITHYRUS INSULARIS (F. Sm.). — Recorded only from the Boreal Zone: Alger, Schoolcraft, Luce, Chippewa, Mackinac, Emmet, and Charlevoix counties. Host unknown in Michigan. Rare.

PSITHYRUS LABORIOSUS (Fab.). — Seems to be associated with all three zones, having been taken in Marquette, Delta, Menominee, Chippewa, Mackinac, Cheboygan, Grand Traverse, Midland, Huron, Ingham, Livingston, Oakland, Washtenaw, and Monroe counties. Hosts: both *B. vagans* and *B. impatiens* (Plath, 1934). Not common.

PSITHYRUS LABORIOSUS var. CITRINUS (F. Sm.). — Follows closely the distribution of the typical species, having been recorded from Mackinac, Cheboygan, Otsego, Grand Traverse, Midland, Huron, Oakland, and Washtenaw counties. Hosts: principally *B. vagans* (Bequaert and Plath, 1925) and *B. impatiens*. Not common.

PSITHYRUS FERNALDAE Fkln. — Recorded in but four counties in the state: Keweenaw, Gogebic, Cheboygan, and Huron. Probably associated chiefly with the Boreal Zone; extends somewhat into the Transition. Host unknown. Rare.

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EXPERIMENTS IN THE USE OF BRUSH SHELTERS BY FISH IN MICHIGAN LAKES *

IMMANUEL A. RODEHEFFER

IN THE recent development of the lake-improvement aspect of game-fish management artificial shelters of brush and other material have been installed in the hope of bettering the conditions for fish life (Hubbs and Eschmeyer, 1938). Proposals for shelter improvement have met with ready acceptance as relief labor projects since such projects utilize much unskilled labor and involve only a small outlay of money for materials. As a consequence, many thousands of brush shelters have been made and sunk in the inland lakes of the northern states, at a reported cost of several hundred thousand dollars. Very little effort and money have been expended, however, in any extensive and adequate attempt to test the success of these structures. Few men of competent training have been available to make such tests, and the supervisors of the emergency conservation work have not found it possible or expedient to support the research which might have placed environmental control on a more secure and permanent basis.

In supplying some needed evaluations of the effectiveness and practicability of brush shelters, and in planning the continuation of such studies, it was gratifying to have the coöperation of the Biological Station of the University of Michigan and of the Institute for Fisheries Research of the Michigan Department of Conservation. Dr. George R. La Rue, director of the Biological Station, and Dr. A. S. Hazzard, director of the Institute for Fisheries Research, are particularly thanked for aid, encouragement, and equipment. Civilian Conservation Corps labor was provided by the Michigan Emergency Conservation Work. Dr. Carl L. Hubbs gave advice and other help in the investigation and in the preparation of this report.

* Contribution from the Biological Station of the University of Michigan and the Institute for Fisheries Research of the Michigan Department of Conservation.

Some data on the use of brush shelters by fish, obtained by Dr. R. W. Eschmeyer of the Institute for Fisheries Research in 1934, have kindly been made available for inclusion here.

So far as has been recorded, the first detailed observation on the effect of brush shelters was made on October 25, 1931, by Dr. Carl L. Hubbs and party, representing the Institute for Fisheries Research. A relatively small pile of brush had previously been placed by Mr. Eugene R. Kuhne in Crystal Lake, Oceana County, Michigan, on its sandy shoal, which otherwise was almost devoid of natural protection for fish. After a large minnow seine had been set around this shelter the brush was removed and the net pulled to shore. The number of fish in this haul, 6,941, was astounding when compared with the 48 seined in a similar area, but where there was no brush (Hubbs and Hubbs, 1933, p. 617; Hubbs and Eschmeyer, 1938, pp. 203–205, fig. 72).

During following summers lake-survey parties of the Institute for Fisheries Research made and placed shelters in various Michigan lakes as part of an experimental lake-improvement program. Soon after the Civilian Conservation Corps was organized in 1933 lake improvement was accepted as one of the projects of the organization, and several temporary agencies took part in this work. As a result, it suddenly developed into a major fisheries activity in Michigan, Wisconsin, Iowa, and other states, where most of this activity consisted of the building and installing of brush shelters. Various types of shelters were devised (Hubbs and Eschmeyer, 1938, pp. 63–86).

The removing of shelters to test their effectiveness (Tarzwell, 1936, p. 432) was continued by Dr. R. W. Eschmeyer during the summer of 1934 and by the writer in the summer of 1937. The discussion below represents a summary of the findings of these two summers' work.

TESTS IN DOUGLAS LAKE

Brush shelters were installed in Douglas Lake, Cheboygan County, Michigan, in the summer of 1937, and were studied to determine the extent to which introduced brush shelters are used by fish and the size and species of game fish found in them. Other studies essential to a full evaluation of the shelters were made, but a report of them will be delayed pending the completion of further investigations. Among these studies are ones dealing with differences in the fish populations sheltered by night and by day, the value of adding

fertilizers in the shelters, their use as permanent summer habitats, and the extent to which they become repopulated after the removal of all fish.

The work was started in Douglas Lake on the shoal between Grapevine Point and the boathouse of the Michigan Biological Station. In this area, which is somewhat protected from the prevailing northwest winds, the bottom consists almost entirely of sand, with some stony patches near shore. The slope is gradual, leading to a depth of 8 to 12 feet at the sharp drop-off about 100 feet from shore. The shoal is almost devoid of vegetation, but there are some submerged plants on the slope beyond the drop-off. In one of the control areas (D; see Table II) a few dozen plants of *Potamogeton heterophyllus* were growing near shore, and in places there was some waterlogged timber, partly covered with sand.

The 140-foot seine used for all the test seinings was made of $\frac{1}{4}$-inch mesh in the bag, of $\frac{3}{8}$-inch mesh next to the bag, and of $\frac{7}{8}$-inch mesh at the ends of the wings.

To determine what fish were in the area before shelters were installed five seine hauls were made at more or less regularly spaced intervals, roughly estimated as 100 feet, on the afternoon of July 12, 1937. The small number of fish obtained in these seinings (Table I) gives some indication of the barrenness of this area in fish life before improvement was attempted. The largest catch was taken in haul number 1 (where shelter 1 was placed later), just south of a rather deep, protected cove which lies to the south of Grapevine Point. Dr. Charles W. Creaser (personal communication) has found this cove a favorable spot for taking fish for his ichthyology classes at the Biological Station.

After the seining, ten brush shelters (Table II) were built and placed in this region. Shelters designated as "green brush" were made of poplar, tag alder, cherry, maple, and scrub oak. Number 3 was constructed by placing the butts of two green treetops opposite each other and wiring them together. Number 4 was a compact mass of pine branches fastened to a hardwood frame. Rocks placed in baskets of wire fencing formed shelter number 5. Waterlogged timber removed from the bottom of the shoal area was used for shelter 6, and dry deadwood, cherry, and tag alder brush made up shelter number 7.

These shelters were set about 80 feet apart, except where control

TABLE I

SPECIES, NUMBER, AND SIZE OF FISH TAKEN IN FIVE SEINE HAULS ON JULY 12, 1937, IN THE AREA WHERE BRUSH SHELTERS WERE LATER INSTALLED

Lengths estimated in centimeters.

Species	Haul number									
	1		2*		3		4		5†	
	Number of fish	Length	Number of fish	Length	Number of fish	Length	Number of fish	Length	Number of fish	Length
Small-mouthed bass (*Micropterus dolomieu*)	3	3–15	4	3–8	..	..	..	..	1	9
Rock bass (*Ambloplites rupestris*)	..	..	1	6	..	..	..	..	..	..
Pumpkinseed (*Eupomotis gibbosus*)	1	6	1	6	..	..	..	..	..	.
Yellow perch (*Perca flavescens*)	2	4	..	..	..	.	..	..	..	..
White sucker (*Catostomus commersonnii*)	6	2–6	..	..	.	..	..	..	..	..
Sand shiner (*Notropis deliciosus*)	29	5–8	..	..	..	..	..	..	..	.
Common shiner (*Notropis cornutus frontalis*)	2	8	..	..	..	..	..	..	..	..
Spot-tailed shiner (*Notropis h. hudsonius*)	13	5–8	..	..	..	..	..	..	..	..
Blunt-nosed minnow (*Hyborhynchus notatus*)	17	5–8	..	..	..	..	..	..	1	6

* Probably not a representative haul, since the seine snagged on the bottom.

† Four to five dozen small minnows (about 1 inch long) were seen going through meshes of the net.

areas were designated. Here the installations were approximately 180 feet apart, which permitted the use of a section where a shelter might have been placed as a control area.

Before the shelters were removed a seine was laid from a boat around them to form a semicircle, with the open part toward the shore. The shelters were then pulled shoreward, and the net was carefully drawn along behind.[1] Fish captured were counted, measured, identified, and fin-clipped, after which they were returned to the lake, near shore (to determine whether they remained in the area). Each shelter was restored to its original position before others

[1] Shelter 5, made of rocks, could not be moved. The net was set as usual, after which efforts were made to drive all fish from the shelter. Then the net was carefully lifted over the rocks, but it is possible that numerous fish escaped.

TABLE II

Summary of Information on Ten Brush Shelters Placed in Douglas Lake and Removed at Intervals

Control areas were as follows: A between shelters 2 and 3, B between shelters 4 and 5, C between shelters 6 and 7, D between shelters 8 and 9, E south of shelter 10.

Shelter number	Size of shelter (feet)	Date of placement (1937)	Material used	Condition of shelter	Dates of removal (1937)	Distance from shore (feet)	Depth of shelter (feet)
1 *	10 × 10 × 1½	July 14	Green brush	Compact, untrimmed	Aug. 2, 4, 6, 23, 25	90	5–6
2	10 × 10 × 1½	July 14	Green brush	Compact, untrimmed	July 20, Aug. 2, 23	80	5–6
3	12 × 3 × 2	July 14	Two treetops	Loose, untrimmed	July 19, Aug. 2, 4, 6, 23, 24, 25	102	5–6
4 *	10 × 6 × 2	July 14	Evergreens on hardwood frame	Compact, untrimmed	Aug. 2, 4, 6, 23	88	5-6
5	6 × 6 × 1	July 16	Rock pile in wire basket	4 wire baskets of rocks	Aug. 4, 24	78	5–6
6	8 × 12 × 2	July 16	Waterlogged timbers	Loosely piled	Aug. 4, 24	75	5–6
7 *	10 × 10 × 1	July 16	Dry deadwood	Compact, untrimmed	Aug. 4, 23	89	5–6
8 *	10 × 10 × ½	July 19	Green brush	Compact, untrimmed	Aug. 6, 23, 24, 25	92	5–6
9 *	8 × 10 × 1	July 19	Green brush	Compact, untrimmed	Aug. 4, 6, 24	79	5–6
10	8 × 10 × 1	July 19	Green brush	Compact, untrimmed	Aug. 4, 24	92	5–6

* Two burlap bags of barnyard manure were placed on shelter 1; one bag each was placed on shelters 4, 7, 8, and 9.

were disturbed. Control areas were seined to note what number and species of fish lived in the open areas.

Some seining and removing of shelters were done at night in an effort to discover to what extent the fish population inhabiting the shelter and control areas differed by night and by day.

TESTS IN LAKES OF PRESQUE ISLE AND MONTMORENCY COUNTIES

Shelters were installed in Clear, Jackson, Rush, and Tomahawk lakes of Montmorency County, and in Ess Lake in Presque Isle County, Michigan, in the summer of 1934. Later in that season studies were made by Dr. Eschmeyer of the fish inhabiting these covers, by methods similar to those mentioned above. The purpose was to determine the fish population in and immediately about them.

A total of twenty-six experimental shelters, ranging in size from $3 \times 5 \times 1$ feet to $6 \times 6 \times 2$ feet, were placed in these lakes at a depth of 2 to 6 feet, and later withdrawn. They were made smaller than usual to facilitate removal. Green brush of tag alder, willow, poplar, cherry, oak, hawthorne, and jack pine was used.

The fifteen shelters in Clear Lake were placed on a sandy or a gravel bottom, free of all vegetation, between August 14 and August 17 and were removed on August 30 and September 4. Two shelters were put in Jackson Lake on August 24 on a sand, gravel, and marl bottom, one where there was no vegetation, the other in abundant vegetation. These two were withdrawn on September 5. In Rush Lake three shelters were put among sparse vegetation on a sand and marl bottom on August 27 and were removed on September 6. Three were placed in Tomahawk Lake on August 22 on a pulpy peat and sandy bottom devoid of vegetation. They were taken out on September 5. In Ess Lake three were installed on August 30 and 31 on a sand, marl, and pulpy peat bottom where vegetation flourished. These were removed on September 6.

RESULTS OF SEINING OPERATIONS FOR 1934 AND 1937

Table III summarizes the data obtained from the seine hauls made about the shelters as they were withdrawn, and from hauls made in the control areas.

It was found that rock bass (*Ambloplites rupestris*) were the most common fish in and around shelters in Douglas Lake, and that this

TABLE III

NUMBER AND KIND OF FISH FOUND IN SHELTERS (S) AND CONTROL AREAS (C) IN SIX MICHIGAN LAKES

Figures in parentheses indicate number of seinings about given shelters or in control areas.

Kind of fish; crayfish	Name of lake												Total in all lakes		Number of fish per seine haul in shelters	Number of fish per seine haul in control areas
	Clear Lake		Jackson Lake		Rush Lake		Tomahawk Lake		Ess Lake		Douglas Lake					
	S(15)	C(13)	S(2)	C(2)	S(3)	C(3)	S(3)	C(3)	S(3)	C(3)	S(36)	C(23)	S(62)	C(47)		
Small-mouthed bass	106	23	4	0	80	17	2	2	1	2	157	71	350	115	5.65	2.45
Large-mouthed bass	...	..	11	0	4	0	4	8	5	0	22	3	46	11	.74	.23
Rock bass	35	0	1	0	53	0	..	..	72	7	1465	9	1626	16	26.23	.34
Pumpkinseed	...	..	5	0	3	0	52	4	106	4	253	24	419	32	6.75	.68
Sunfish*	...	..	2	0	...	..	...	..	8	0	....	...	10	0	.16	0
Bluegill	...	..	3	0	15	0	8	0	...	...	2	0	28	0	.45	0
Yellow perch	114	0	7	1	23	22	14	7	56	63	517	200	731	293	11.79	6.23
Pike	...	..	...	..	0	2	...	..	...	...	....	...	0	2	0	.04
Total game fishes	255	23	33	1	178	41	80	21	248	76	2416	307	3210	469	51.77	9.98
Coarse fish†	1	0	...	..	3	0	...	..	135	4	64	46	203	50	3.27	1.06
Forage fish and darters‡	69	2	1	0	0	3	137	24	579	104	198	222	984	355	15.87	7.55
Total fish	325	25	34	1	181	44	217	45	962	184	2678	575	4397	874	70.92	18.60
Crayfish	357	13	343	5	134	6	48	8	34	51	....§	...§	916	18	.....	.....
Total fish and crayfish	682	38	377	6	315	50	265	53	996	235	2678	575	5313	892	.....	.....

* Sunfish not identified.

† White suckers and bullheads.

‡ Includes blunt-nosed minnow, black-nosed shiner, spot-tailed shiner, sand shiner, common shiner, mud minnow, Johnny darter, Iowa darter, log perch, and trout perch.

§ No definite count kept; very few taken.

species also occurred at the small shelters installed in other lakes. Very few rock bass were taken in control areas.

Perch (*Perca flavescens*), found commonly in all six lakes, ranked second in abundance around the shelters in Douglas Lake; in the control areas in this lake more of this species than of any other were recorded.

Pumpkinseed sunfish (*Eupomotis gibbosus*) ranked third among the pan and game fish from around the shelters in Douglas Lake and were taken commonly in the other lakes, except Clear Lake.

Small-mouthed bass (*Micropterus dolomieu*) were captured about the shelters in all the lakes. In Douglas Lake this species ranked fourth among the pan and game fishes around the shelters, and next to perch in the control areas.

More work is needed to prove whether these data are indicative of the use by fish of shelters in general,[2] but the results of seining sixty-two shelter areas and forty-seven control areas indicate quite definitely that rock bass will congregate in and around shelters to a very considerable extent. Since rock bass tend to become stunted in northern lakes, they are of little or no value as game fish. For this reason shelters may at times prove detrimental to fishing (Eschmeyer, 1936, p. 336) through the increase in the numbers of stunted fish. The ratio of pumpkinseeds in shelters to those in control areas shows that this species prefers shelters, whereas perch and small-mouthed bass apparently are of more free-swimming habits, since they were taken in comparatively large numbers in both environments.

Of particular interest is the number of crayfish from shelters in the five lakes in Montmorency and Presque Isle counties, where they congregated in or under shelters in large numbers. No definite count of crayfish in Douglas Lake was kept, but they were not numerous. The total collected in one day's seining of shelter and control areas was only 32.

SIZE AND SPECIES OF GAME FISH TAKEN

In Douglas Lake the total length of the game fish caught was recorded (Table IV) to determine the size of the fish which lived in or near shelters.

It may be noted that rock bass were most numerous in two sizes

[2] The available data on each type of shelter used are not reported upon in this paper. It is hoped that a more intensive study of this phase of the work may be made in the future.

TABLE IV

LENGTH IN CENTIMETERS OF GAME FISHES TAKEN IN BRUSH SHELTERS (S) AND CONTROL AREAS (C) IN DOUGLAS LAKE

Size in cm.	Rock bass		Perch		Pumpkinseed		Smallmouthed bass		Largemouthed bass	
	S	C	S	C	S	C	S	C	S	C
1–2	...	..	...	..	..	..	1	..	..	..
2–3	16	3	...	..	4	..	..	..	..	..
3–4	42	1	4	2	18	..	1	..	..	..
4–5	9	..	63	79	2	..	5	14	2	..
5–6	53	..	24	59	1	..	22	17	6	3
6–7	217	2	1	2	3	..	26	13	4	..
7–8	68	1	1	..	7	..	25	8	5	..
8–9	147	..	6	1	5	..	11	3	..	..
9–10	381	1	58	10	49	4	4	1	2	..
10–11	207	..	30	7	57	7	1	1	..	..
11–12	86	..	35	7	29	3	3	1	..	..
12–13	57	1	103	9	26	3	5	2	..	..
13–14	52	..	103	14	15	3	15	4	..	..
14–15	14	..	40	6	12	2	11	2	..	..
15–16	19	..	18	1	5	..	8	2	..	..
16–17	29	..	2	1	6	1	7	1	1	..
17–18	10	..	2	1	2	1	2	..	1	..
18–19	7	..	4	1	1	..	1	..	..	..
19–20	3	..	1	..	1	..	..	..	..	..
20–21	5	..	...	..	1	..	..	..	..	..
21–22	1	..	...	..	..	..	..	..	..	..
22–23	...	..	...	..	..	..	3	..	..	..
26–27	...	..	...	..	..	..	1	1	..	..
Mean size	9.4	5.9	11.0	7.1	10.1	12.0	9.6	7.7	7.5	5.5

(age groups?), namely, from 6 to 7 centimeters long (about $2\frac{1}{2}$ inches) and from 9 to 10 centimeters long ($3\frac{1}{2}$ to 4 inches). Only 55 of the 1,465 rock bass taken were of legal size (6 inches or longer).

Perch of 12 and 13 centimeters (about 5 inches) were more common than those of other sizes. Only 9 of the 517 taken were of legal size, but this fish, like the rock bass, is greatly dwarfed in Douglas Lake (Weller, 1938).

Of the 253 pumpkinseed sunfish taken 112 measured between 9 and 11 centimeters ($3\frac{1}{2}$ to $4\frac{1}{4}$ inches) and 11 were of legal size.

Small-mouthed and large-mouthed bass captured about the shelters were small. Seventy-three of the 157 small-mouthed bass ranged from 5 to 8 centimeters (2 to 3 inches), and only 1 was over 10 inches. Of the 22 large-mouthed bass, 15 measured from 5 to 8 centimeters (2 to 3 inches), the largest being 7 inches long.

In the investigations on the five other lakes during the season of 1934 only 1 of the 161 rock bass from the shelters was large. Eight of the 214 perch were listed as half grown and all others were small. Only 1 pumpkinseed of the 166 taken was recorded as half grown. Five of the 193 small-mouthed bass captured were designated half grown. Of the large-mouthed bass taken, all were listed as young.

The data from the control areas show that only 9 rock bass were taken in Douglas Lake, of which 6 were less than 7 centimeters long (less than 3 inches). Of the 200 perch 138 were from 4 to 6 centimeters long (about $1\frac{1}{2}$ to $2\frac{1}{2}$ inches). Ninety-three of this size range were taken in one seine haul. Of the 24 pumpkinseed only 2 were over legal size, and the 70 small-mouthed bass included only 1 that was more than 10 inches in length. The 3 large-mouthed bass were all 5 centimeters long.

EFFECTIVENESS OF SHELTERS

From the data here presented it may be concluded that young game fishes seek the protection of shelters. Of the forage fishes, the blunt-nosed minnow (*Hyborhynchus notatus*) shows a decided preference for such protection. Suckers (*Catostomus commersonnii*) were the largest fish taken, ranging from 35 to 40 centimeters in length (14 to 16 inches), but the young of this fish also sought the shelters.

This study merely indicates the effectiveness of shelters in concentrating fish in a given area in a lake. It has not been determined to what extent their presence may increase the fish population of an entire lake.

Many problems may be presented in connection with the protection of fish in shelters. The effects of the induced concentrations of fish on the food supply, stunting of growth, parasitization, and disease are among questions in need of study.

It may be supposed that brush shelters attract large fish in search of smaller fish for food. An investigation has been started on another lake in Michigan to determine the value from the angler's point of

view of large shelters which attract big fish to waters of moderate depth. In connection with such lures the problem arises whether the catching of fish is rendered so easy as to lead to overfishing and the depletion of the stock.

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THE AGE, GROWTH, SEXUAL MATURITY, AND SEX RATIO OF THE COMMON WHITEFISH, *COREGONUS CLUPEAFORMIS* (MITCHILL), OF LAKE HURON *

JOHN VAN OOSTEN

I. INTRODUCTION

THE common whitefish, *Coregonus clupeaformis* (Mitchill), is the largest and most widely known species of the coregonid group. This species is eminently a lake fish and is distributed from Labrador through New Hampshire to western New York and the Great Lakes through Wisconsin and Minnesota to northern British Columbia. In the Great Lakes whitefish seldom occur in any large numbers at depths greater than 160 feet. In the spring and early summer they concentrate in shallow water less than 60 feet in depth; in July and August they migrate into deeper water (in Lake Huron their maximum density in summer occurs between depths of 80 and 110 feet; in Lake Michigan, at depths between 60 and 90 feet) and return in the fall to the shallower water, where they probably remain until the ice breaks up. Whitefish are gregarious and travel in schools. The Great Lakes form reaches a weight of at least 26 pounds although the average weight is now about 3 pounds. In general, the whitefish spawn during November and the first half of December on sand, gravel, stone, or honeycomb rock bottom at depths of 6 to 60 feet. The males as a rule do not become sexually mature until they attain a weight of from $1\frac{1}{2}$ to $2\frac{1}{2}$ pounds, varying with the lakes and the localities within a lake, and the females do not reach maturity at a weight much less than 3 pounds.

The first food of the whitefish consists of Entomostraca, which are later supplemented by insect larvae and amphipods. The adult whitefish is primarily a bottom feeder, subsisting largely on am-

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phipods (*Pontoporeia*), mollusks (the small varieties), and insect larvae, mainly midges (Chironomidae).

On the Great Lakes the whitefish ranked fifth in the commercial catch (sixth in United States waters) in 1934, the last year for which complete statistics are available, although in value it ranked second, being surpassed only by the lake trout. The total catch amounted to 10,306,800 pounds, with a value to the fishermen of $1,246,956, of which yield 6,276,000 pounds (value $803,568), or 60.9 per cent, were produced by United States fishermen. No whitefish were exported by the United States, but 10,016,034 pounds, valued at $945,164, were imported from Canada, so that the total United States consumption of this species amounted to 16,292,034 pounds, valued at $1,748,732.

As is shown in Table I, Lakes Huron and Michigan produced the most whitefish in 1934, contributing 76 per cent of the United States

TABLE I

Distribution of the 1934 United States Catch of Whitefish on the Great Lakes by Lakes, States, and Type of Gear

Lake	Pounds	Per-centage	State	Pounds	Per-centage	Gear	Pounds	Per-centage
Ontario..	83,600	1.3	New York...	118,200	1.9	Trap nets..	2,899,300	46.2
Erie.....	777,400	12.4	Pennsylvania	462,900	7.4	Gill nets...	2,108,300	33.6
Huron...	2,565,800	40.9	Ohio.....	278,900	4.4	Pound nets	1,254,900	20.0
Michigan	2,181,800	34.8	Michigan...	4,890,800	77.9	Fyke nets..	12,600	0.2
Superior.	493,200	7.8	Indiana.....	3,900	0.1	Trot lines..	900	x †
Boundary			Illinois.....	700	x †			
lakes *.	174,200	2.8	Wisconsin...	336,800	5.4			
			Minnesota..	183,800	2.9			

* Namakan, Rainy, and Lake of the Woods in Minnesota.
† x = less than 0.1 per cent.

yield. The state of Michigan yielded 78 per cent of this total catch. Trap nets took 46 per cent, gill nets 34 per cent, and pound nets 20 per cent of the whitefish caught in 1934 in United States waters. In general, the heaviest production occurs in June and July. The question of abundance will be discussed in detail in a paper to be published elsewhere, but it may be mentioned here that the whitefish of all the Great Lakes has undergone serious depletion in spite of the fact that it has always been one of the species most heavily propagated artificially on these lakes and that it has been protected in some

measure by all the states through the establishment of a minimum size mesh in the nets of capture, by closed seasons, and by minimum size limits.

Nothing has been published on the age and growth of the Lake Huron whitefish except the few data on some seventy-six specimens collected at Alpena, Michigan, in 1917, which data appeared in connection with a study of the scale theory (Van Oosten, 1923), and a paragraph presenting a summary of my preliminary findings on the Lake Huron whitefish collected in 1923 (Higgins, 1928, p. 535). Such information has, however, been recorded for the whitefish of Lake Erie (Couch, 1922), of Lake Ontario (Hart, 1930 and 1931), and of several of the smaller North American inland lakes. For a good general account of the natural history of the whitefish in the Great Lakes the reader is referred to Koelz (1929).

II. MATERIALS AND METHODS

This study on the age and growth of the whitefish is based on 982 specimens examined at Alpena, Michigan, on July 3 and 10, 1923, and on November 15, 17, and 19, 1924. The 205 fish taken on July 3, 1923, were obtained with $4\frac{1}{2}$-inch mesh gill nets set 3 miles ESE from the Can Buoy off Alpena in 15–16 fathoms of water on a reef and black mud bottom. The 247 individuals collected on July 10, 1923, were captured in the same kind of gear set 3 miles E $\frac{1}{2}$ S from North Point in 14–20 fathoms of water on a rock and mud bottom. All the 1924 materials, except 21 fish taken on November 15, were collected with $4\frac{1}{2}$- to 5-inch mesh gill nets set on the North Grounds 7 miles NNE of Thunder Bay Island in 5–9 fathoms of water on clay and mud bottom. The 21 specimens were caught in a pound net set off Sulphur Island Reef in 36–41 feet of water on mud bottom. A careful analysis showed no important differences in the age and growth characteristics of the fish of the different samples collected in the same year. Hence the individuals taken in the same year were considered a homogeneous group. The data on the relationship of standard to total length were based on 1,582 whitefish taken with deep trap nets and pound nets and measured at various ports on Lake Huron during the period 1928–35.

The fish were measured and weighed fresh in the field. Length measurements made with a steel tape were recorded in millimeters and weights in pounds and ounces. All growth computations were

based on the measurement of the diameter of the projected images of the scales, and the calculations were made on the assumption that the body-scale ratio remained constant at all times after the completion of the first annulus. Ages are expressed by Roman numerals and indicate the number of annuli found on the scales. In the determination of sexual maturity all fish with enlarged gonads, whether turgid or flabby (spent), were designated mature; it was assumed that these unspent individuals would spawn in the fall of the year of capture. Specimens with small, thin, transparent gonads were called immature.

I am indebted to Dr. Ralph Hile for valuable assistance given in the preparation of the tables.

III. AGE COMPOSITION AND LENGTH FREQUENCIES

In Tables II and III the whitefish have been divided into age groups and according to the year class to which they belong, with the individuals of each age group arranged according to their standard length. The number of individuals in each age group, the percentage of that number in the combined samples, and the average length of the fish of each group as well as of the entire collection are shown at the bottom of each table. The column at the extreme right of each table gives the number of fish of each size group. In these tables the data for the sexes were combined, since an analysis showed that the length frequencies of the sexes were virtually the same within an age group. In accordance with expectation the summer collections of 1923 were composed of smaller and younger fish (age groups III–VII) than were the fall samples of 1924 taken on the spawning grounds (age groups III–XII). The bulk (92.7 per cent) of the 1923 samples ranged from 380 millimeters (total length 17.6 inches) to 480 millimeters (total length 22.2 inches) in standard length, with an average length of 426 millimeters (total length 19.7 inches). The bulk (89.8 per cent) of the 1924 collections ranged from 440 millimeters (total length 20.4 inches) to 560 millimeters (total length 25.6 inches) in standard length, with an average length of 497 millimeters (total length 23.0 inches). In 1923 age group IV (1919 year class) predominated, comprising 69.7 per cent of the total number aged; age group V (1918 year class) ranked second in abundance, with a percentage of 18.8. In 1924 age group VI (1918 year class) dominated the catch with a percentage of 59.8, and age

TABLE II

FREQUENCY DISTRIBUTION OF THE LAKE HURON WHITEFISH (TAKEN OFF ALPENA, JULY 3 AND 10, 1923), ACCORDING TO STANDARD LENGTH IN MM., AGE GROUP (ROMAN NUMERALS), AND YEAR CLASS (CALENDAR YEARS), WITH SEXES COMBINED

Standard length interval in mm.	Age group					
	III	IV	V	VI	VII	III–VII
	Year class					
	1920	1919	1918	1917	1916	1916–1920
350–359	..	1	..	..	..	1
360–369	1	2	..	..	..	3
370–379	1	3	..	..	..	4
380–389	3	9	1	..	..	13
390–399	3	32	4	..	..	39
400–409	5	52	2	..	..	59
410–419	2	83	4	1	..	90
420–429	3	59	13	1	..	76
430–439	1	40	15	..	..	56
440–449	..	16	13	..	..	29
450–459	..	7	8	2	..	17
460–469	..	4	11	7	..	22
470–479	..	1	11	6	..	18
480–489	..	4	2	2	..	8
490–499	..	1	1	1	1	4
500–509	..	1	..	2	2	5
510–519	..	..	..	1	..	1
520–529	..	..	..	2	3	5
530–539	..	..	..	1	..	1
540–549	..	..	..	..	1	1
Total number.....	19	315	85	26	7	452
Percentage in sample	4.2	69.7	18.8	5.8	1.5	100.0
Average length.....	401	417	442	476	517	426

group VII (1917 year class) ranked second with a percentage of 15.5. It is to be noted also that the average length of the fish of each age group, VII excepted, taken in 1923 is less than that of the specimens of corresponding age groups collected in 1924. These discrepancies in size may no doubt be accounted for in large part by the incomplete summer's growth of the 1923 fish as well as by the fact that these fish included immature individuals, whereas the 1924 specimens

TABLE III

FREQUENCY DISTRIBUTION OF THE LAKE HURON WHITEFISH (TAKEN OFF ALPENA, NOVEMBER 15, 17, AND 19, 1924), ACCORDING TO STANDARD LENGTH IN MM., AGE GROUP (ROMAN NUMERALS), AND YEAR CLASS (CALENDAR YEARS), WITH SEXES COMBINED

Standard length interval in mm.	Age group										
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	III–XII
	Year class										
	1921	1920	1919	1918	1917	1916	1915	1914	1913	1912	1912–1921
370–379	...	...	1	...	...	...	...	...	...	...	1
380 389	...	...	...	...	...	...	...	...	...	...	...
390–399	2	...	...	...	...	...	...	...	...	...	2
400–409	3	1	...	...	...	...	...	...	...	...	4
410–419	1	4	...	...	...	...	...	...	...	...	5
420–429	2	4	1	...	1	...	...	...	...	...	8
430–439	1	1	1	1	...	...	...	...	...	...	4
440–449	...	2	7	4	...	...	...	...	...	...	13
450–459	...	2	2	10	...	...	...	...	...	...	14
460–469	...	2	1	26	1	...	...	...	...	...	30
470 479	...	...	8	52	2	...	...	...	...	...	62
480–489	...	3	3	65	4	...	...	...	...	...	75
490–499	...	2	5	47	11	...	...	...	...	...	65
500–509	...	1	2	61	15	2	...	...	...	...	81
510–519	...	1	2	29	14	2	1	1	...	...	50
520–529	...	...	...	14	16	...	2	...	...	...	32
530 539	...	...	...	4	8	2	1	1	...	...	16
540–549	...	...	...	2	4	3	3	...	...	...	12
550–559	...	...	1	1	4	5	9	4	...	2	26
560–569	...	...	...	...	2	1	5	...	...	...	8
570–579	...	...	...	...	...	1	7	...	...	...	8
580–589	...	...	...	1	...	...	1	2	3	...	7
590–599	...	...	...	...	...	1	1	2	...	...	4
600–609	...	...	...	...	...	...	...	2	...	...	2
610–619	...	...	...	...	...	...	1	...	...	...	1
Total number.....	9	23	34	317	82	17	31	12	3	2	530
Percentage in sample	1.7	4.3	6.4	59.8	15.5	3.2	5.8	2.3	0.6	0.4	100.0
Average length.....	409	450	470	490	513	542	559	569	585	555	497

were all mature. Further, the 1923 fish were captured with a smaller-meshed gill net (4½ inches) than were the fish of 1924 (4½–5 inches). Even so, exact correspondence in average growth rates cannot be expected of fish in the same age group but of different year classes, since growth conditions do not as a rule remain constant from year to year.

The data show clearly that the gill nets drew upon a younger stock of whitefish in the summer than they did in the fall. If the samples are representative of the age composition of the catch of both seasons then it may be concluded that each year class is subjected to intensive gill-net fishing at least twice, first during the summer after the fish reach an age of four years and then during the fall after they reach an age of six years. Each year class likewise forms an important component of the catch in summer after it reaches the age of five years and in the fall during its eighth year of life. It would seem, then, that each year class contributes an important percentage to the catch of gill nets for at least four consecutive years — two successive summers and two consecutive autumns.

IV. GROWTH IN LENGTH AND WEIGHT

Tables IV and V show for each sex of the Lake Huron whitefish and for the sexes combined the average length and weight at capture and the average calculated length in millimeters attained by the various age groups (and year classes) at the end of each year of life. The grand averages of length and increments in length are given at the bottom of each table. Inspection of Table IV shows that in the well-represented age groups practically no differences existed between the average lengths of the sexes at the time of capture, but that the females weighed slightly more on the average (about 2.2 oz.) than the males. The computed lengths for these age groups likewise indicate that no significant differences in growth rate occurred between the sexes. The grand averages of length of the males and females are nearly identical. Because of the paucity of females the 1924 data of Table V are not adequate for a comparison of the growth rates of the sexes. Nevertheless, the best represented age groups (VI and VII), as well as the grand averages, tend to substantiate the foregoing conclusions founded on the 1923 data. Further discussions of growth based on lengths will rest on the averages of the sexes combined.

TABLE IV

LAKE HURON WHITEFISH TAKEN OFF ALPENA, JULY 3 AND 10, 1923. AVERAGE LENGTH AND WEIGHT AT CAPTURE AND AVERAGE CALCULATED LENGTH ATTAINED BY THE VARIOUS AGE GROUPS (AND YEAR CLASSES) AT THE END OF EACH YEAR OF LIFE

Eleven nonsexed fish were included in the averages for the sexes combined in the IV group and one in the V group.

Year class	Age group	Sex	No. of specimens	Weight in pounds	Increment in weight	Total length in inches	Weight in grams	Standard length in mm.	Calculated standard length in mm. attained at end of year						
									1	2	3	4	5	6	7
1920	III	Male	8	2.19	...	18.8	993	407	147	246	337	...	...	...	...
		Female	11	2.09	....	18.4	948	398	140	225	322	...	...	...	...
		Male and female	19	2.14	....	18.6	971	401	143	234	328	...	...	...	...
1919	IV	Male	157	2.33	0.14	19.2	1,057	416	112	195	271	355	...	...	...
		Female	147	2.44	0.35	19.4	1,107	419	112	196	275	358	...	...	...
		Male and female	315	2.39	0.25	19.3	1,084	417	112	196	272	356	...	...	...
1918	V	Male	36	2.78	0.45	20 5	1,261	442	92	181	249	330	398	...	...
		Female	48	2.96	0.52	20 5	1,343	443	97	183	250	325	397	...	...
		Male and female	85	2.87	0.48	20.5	1,302	442	94	182	249	327	398	...	...
1917	VI	Male	12	3.47	0.69	22.1	1,574	478	119	186	257	333	404	451	...
		Female	14	3.62	0.66	21.9	1,642	474	116	182	252	321	393	445	...
		Male and female	26	3.55	0.68	22 0	1,610	476	117	184	254	327	398	448	...
1916	VII	Male	2	4.63	1.16	23.5	2,100	509	109	190	264	347	406	452	478
		Female	5	4.77	1.15	24.1	2,164	520	102	187	258	337	414	463	497
		Male and female	7	4.73	1.18	23.9	2,145	517	104	187	259	340	412	460	492
Grand average calculated length (males) *									109	192	266	349	417	464	490
Grand average calculated length (females) *									109	192	267	348	420	471	505
Grand average calculated length (sexes combined) *									109	192	266	348	419	469	501
Grand average calculated growth increment (sexes combined)									109	83	74	82	71	50	32

* The grand average calculated lengths were determined by the successive addition of the weighted mean of the average annual growth increments of all age groups except III, which was not representative, being composed of the larger individuals.

It is obvious from a comparison of the computed lengths that the III-group fish of Tables IV and V are not representative of their age group in the lake, but are composed of the larger and more rapidly growing individuals of their year class. Unquestionably this selection was done by the 4½-inch mesh gill nets, the gear of capture. Age groups IV and V of Table V also seem to be represented by the faster-growing individuals of their respective year classes. This selection was no doubt due to the segregation of the fish into spawning schools. It has been fairly well established among fishes that the faster-growing individuals of a year class are the first to reach sexual maturity. The data on sexual maturity (Tables XI and XII) indicate that a certain percentage of the whitefish of age groups IV and V are still immature. Because of the nonrepresentativeness of the age groups III, IV, and V referred to above, their computed lengths were not included in the grand averages shown at the bottom of the tables.

The two factors of selectivity (gill net and sexual maturity) also account for the discrepancies in the computed lengths of the fish that belong to the same year class, but were collected in different years. Gear selection accounts for the discrepancies in the 1920 year class. The younger fish of this year class taken in 1923 (age group III) and represented by the larger members of the brood grew more rapidly than the older individuals captured in 1924 (age group IV) and represented by both the smaller and larger individuals. On the other hand, the 1919 and 1918 year classes taken in 1923 and composed of both immature and mature specimens (slower- and faster-growing fish) grew less rapidly than the corresponding year classes captured in 1924 and composed of mature fish only (the slower-growing immature fish were excluded). The calculated lengths of the 1917 and 1916 year classes collected in 1923 also averaged less than those of the corresponding year classes taken in 1924. These results were expected, since it appears that the gill nets used in 1923 could not take fish older than seven years and hence must in all probability have caught the smaller (and slower-growing) individuals of age groups VI and VII.

Tables IV and V also indicate that considerable variation occurred in the growth of the different age groups, especially during the first year of life, when the average length ranged from 94 to 117 millimeters. Such variations are expected in fish that inhabit the

TABLE V

LAKE HURON WHITEFISH TAKEN OFF ALPENA, NOVEMBER 15, 17, AND 19, 1924. AVERAGE LENGTH AND WEIGHT AT CAPTURE AND AVERAGE CALCULATED LENGTH ATTAINED BY THE VARIOUS AGE GROUPS (AND YEAR CLASSES) AT THE END OF EACH YEAR OF LIFE

Nonsexed fish were included in the averages for the sexes combined. Numbers in parentheses indicate number of fish employed.

Year class	Age group	Sex	No. of specimens	Weight in pounds	Total length in inches	Weight in grams	Standard length in mm.	Calculated standard length in mm. attained at end of year											
								1	2	3	4	5	6	7	8	9	10	11	12
1921	III	Male....	4	2.28 (2)	19.6	1,034	423	160	267	372	...	...	...	...	...	...	...	...	...
		Male and female..	9	1.97 (7)	18.9	893	409	149	247	346	...	...	...	...	...	...	...	...	...
1920	IV	Male....	18	2.75 (2)	20.5	1,247	443	125	232	316	392	...	...	...	...	...	...	...	...
		Female..	2	3.25 (2)	22.0	1,474	476	141	248	336	413	...	...	...	...	...	...	...	...
		Male and female..	23	3.12 (7)	20.8	1,415	450	128	235	322	398	...	...	...	...	...	...	...	...
1919	V	Male....	28	2.90 (6)	21.6	1,315	467	118	214	294	369	428	...	...	...	...	...	...	...
		Female..	3	5.38 (1)	20.6	2,440	445	112	215	286	360	411	...	...	...	...	...	...	...
		Male and female..	34	3.78 (10)	21.7	1,715	470	119	220	301	376	433	...	...	...	...	...	...	...
1918	VI	Male....	298	3.07 (32)	22.6	1,393	489	111	190	262	347	411	458	...	...	...	...	...	...
		Female..	17	4.00 (4)	22.9	1,814	494	111	198	270	354	418	466	...	...	...	...	...	...
		Male and female..	317	3.29 (37)	22.7	1,492	490	111	191	263	348	412	459	...	...	...	...	...	...

1917	VII	Male....	72	3.52 (8)	23.7	1,597	513	95	190	264	338	413	458	489	...	...	...	...	...
		Female..	10	5.03 (2)	23.8	2,282	514	90	186	259	339	417	460	494	...	...	...	...	...
		Male and female..	82	3.82 (10)	23.7	1,733	513	94	190	263	338	413	459	490	...	...	...	...	...
1916	VIII	Male....	13	....	24.9	....	539	108	184	264	341	414	468	497	519	...	...	...	...
		Female..	4	5.00 (1)	25.2	2,268	550	120	203	283	365	428	478	512	536	...	...	...	...
		Male and female..	17	....	25.0	....	542	110	188	268	347	417	471	501	523	...	...	...	...
1915	IX	Male....	25	4.57 (2)	25.6	2,073	558	109	194	266	352	422	473	504	526	544	...	...	...
		Female..	6	....	25.6	....	560	102	185	254	343	417	470	508	528	544	...	...	...
		Male and female..	31	....	25.6	....	559	107	192	264	351	422	472	505	526	544	...	...	...
1914	X	Male....	10	4.69 (1)	25.8	2,127	564	118	203	275	344	406	456	490	513	532	547	...	...
		Female..	2	5.75 (1)	27.2	2,608	594	105	185	242	309	389	457	510	547	565	578	...	...
		Male and female..	12	5.22 (2)	26.1	2,368	569	116	200	269	338	403	456	493	518	537	552	...	...
1913	XI	Male....	3	....	26.8	....	585	110	195	266	338	403	460	495	522	539	557	570	...
1912	XII	Male....	2	....	25.4	....	555	101	184	239	302	352	400	438	466	494	514	530	544
Grand average calculated length (males) *								108	190	263	345	412	459	490	513	532	548	562	576
Grand average calculated length (females) *								105	193	265	347	417	466	503	527	543	556	...	...
Grand average calculated length (sexes combined) *								108	191	263	346	412	460	492	514	533	549	563	577
Grand average calculated growth increment (sexes combined)								108	83	72	83	66	48	32	22	19	16	14	14

* The grand average calculated lengths were determined by the successive addition of the weighted mean of the average annual growth increments of all age groups except III, IV, and V, which were not representative, being composed of the larger individuals.

pecially females, have been weighed to provide a good series for study. The males and females taken in 1923 showed such a similarity in average weights that these may be combined and the grand averages employed for the construction of the curves (Fig. 2). Dur-

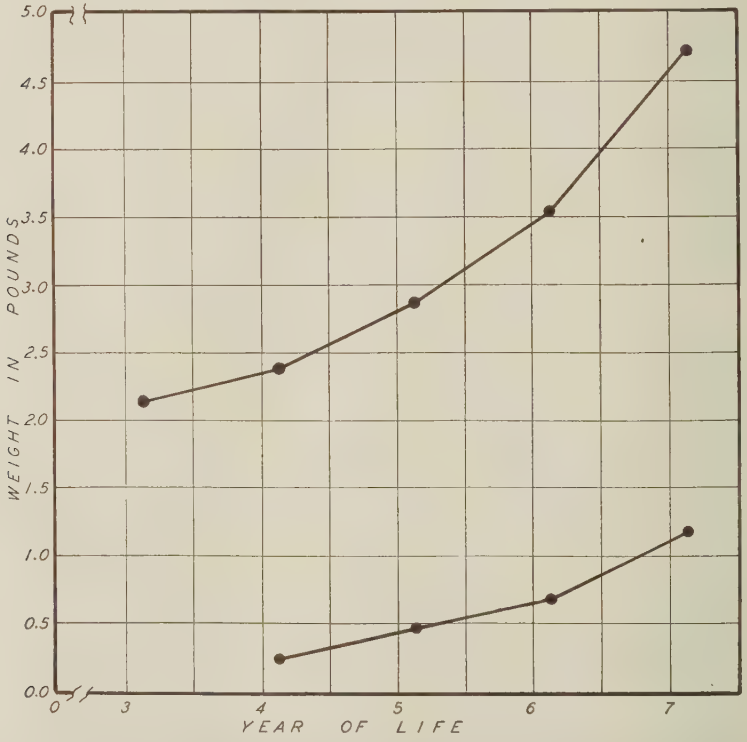

FIG. 2. Upper curve shows average weight in pounds of Lake Huron whitefish during each year of life; lower curve, increments in weight. Data based on grand averages of Table IV

ing the first three and one-fourth years the whitefish attained a weight of 2.14 pounds and a total length of 18.6 inches. Since the fish of age group III represented the faster-growing individuals of their year class the more nearly correct averages are somewhat less than the figures given. The curves of Figure 2 indicate a progressive increase in the annual increment of weight through at least the first

seven and one-fourth years of life, when the fish reached a weight of about 4.7 pounds and a total length of 23.9 inches. At this age the annual weight increment was still large (1.18 pounds or an increase of 33 per cent). From the economic point of view it would be highly desirable to protect the whitefish until at least its eighth year, when it reaches an average length of about 25 inches.

V. GROWTH COMPENSATION

To ascertain whether a compensation in growth occurs in the whitefish the individuals of age group IV taken in 1923 and of age group VI collected in 1924 were divided into three size groups based on the computed lengths for the first year of life (Table VII). The average length of the fish of each size group was then determined for each year of life. From these lengths the average annual increments were derived. The data show that in both age groups (summer and fall collections) the advantage of size reached in the first year was generally maintained throughout life, although the maximum difference between the smallest and the largest individuals decreased progressively with age. The increments indicate quite clearly that a compensation in growth occurs, since the smaller yearlings of each age group grew more rapidly, on the average, than the larger yearlings.

VI. LENGTH–WEIGHT RELATIONSHIP AND COEFFICIENT OF CONDITION

The data showing the relationship between the length and the weight of the male and female whitefish taken off Alpena, July 3 and 10, 1923, are presented in Table VIII and plotted in Figure 3. The open circles in the figure represent the average measurements of the males; the black dots, those of the females. Although the females averaged somewhat more in weight than did the males at corresponding lengths, a single curve expresses quite well the length–weight relationship for both sexes. The curve shows that the weight of the whitefish increases proportionately more rapidly than the length — there is a continuous rise in the curve with increase in fish length.

The curve of Figure 3 has been drawn in such a manner that standard lengths in millimeters may be converted readily to total lengths in inches and vice versa, and weight in grams to weight in pounds and vice versa. The conversion of lengths from one unit

TABLE VII

GROWTH COMPENSATION: COMPUTED AVERAGE STANDARD LENGTH AND AVERAGE INCREMENT OF LENGTH FOR EACH YEAR OF LIFE FOR EACH OF THREE SIZE GROUPS OF THE LAKE HURON WHITEFISH OF AGE GROUP IV COLLECTED IN 1923, WITH SEXES COMBINED, AND OF AGE GROUP VI TAKEN IN 1924, MALES ONLY

The size groups are based on lengths computed for the first year of life.

Age group and year of capture	Size group in mm.	No. of specimens	Average computed length, in mm., for year						Length at capture	Average computed increment of length in year						
			1	2	3	4	5	6		1	2	3	4	5	6	7 *
IV, 1923	Under 100	49	94	184	266	352	...	...	416	94	90	82	86	64 *	..	..
	100–119	209	109	192	268	352	...	...	414	109	83	76	84	62 *	..	...
	Over 119	57	139	218	296	375	...	...	430	139	79	78	79	55 *	..	..
	Maximum difference		45	34	30	23	...	...	16	...	..	..	..	..	..	..
VI, 1924	Under 100	51	93	177	250	334	398	449	482	93	84	73	84	64	51	33
	100–119	205	109	190	261	346	411	458	489	109	81	71	85	65	47	31
	Over 119	42	136	210	282	365	428	472	498	136	74	72	83	63	44	26
	Maximum difference		43	33	32	31	30	23	16	...	..	..	..	..	..	..

* An uncompleted year.

TABLE VIII

LENGTH–WEIGHT RELATIONSHIP FOR EACH SEX OF THE LAKE HURON WHITEFISH TAKEN OFF ALPENA, JULY 3 AND 10, 1923

Males					Females				
Standard length in mm.	Weight in grams	Total length in inches	Weight in ounces	No. of specimens	Standard length in mm.	Weight in grams	Total length in inches	Weight in ounces	No. of specimens
356	652	16.5	23.0	1	366	714	16.9	25.2	3
378	780	17.5	27.5	2	377	794	17.4	28.0	2
384	865	17.8	30.5	6	384	814	17.8	28.7	7
395	930	18.3	32.8	24	395	919	18.3	32.4	15
405	964	18.7	34.0	25	404	1,018	18.7	35.9	31
413	1,040	19.1	36.7	45	413	1,040	19.1	36.7	41
424	1,097	19.6	38.7	37	423	1,128	19.6	39.8	37
434	1,182	20.1	41.7	30	433	1,188	20.0	41.9	23
444	1,256	20.5	44.3	11	444	1,304	20.5	46.0	17
453	1,389	21.0	49.0	8	454	1,457	21.0	51.4	9
462	1,324	21.4	46.7	7	464	1,500	21.5	52.9	15
473	1,488	21.9	52.5	10	473	1,599	21.9	56.4	8
482	1,763	22.3	62.2	4	482	1,865	22.3	65.8	4
495	1,914	22.9	67.5	2	492	1,914	22.8	67.5	2
500	1,531	23.1	54.0	2	504	2,089	23.3	73.7	3
523	2,381	24.2	84.0	1	515	2,268	23.8	80.0	1
...	....	...	...	..	522	2,155	24.1	76.0	4
...	....	...	...	..	533	2,325	24.7	82.0	1
...	....	...	...	..	540	2,438	25.0	86.0	1

of measurement to another was accomplished by the employment of the standard length–total length ratios $\left(\frac{\text{S.L.}}{\text{T.L.}}\right)$ obtained empirically for 1,582 whitefish collected at various ports on Lake Huron during the period 1928-35. The whitefish ranged from 283 to 668 millimeters, standard length. The ratios are shown in the third column of Table IX and were found to range from 0.846 to 0.860, increasing progressively from the smaller to the larger fish. The three size groups in the table were selected after an examination of the ratios of fish grouped in 10-millimeter length intervals. The conclusion with respect to the progressive increase in the $\frac{\text{S.L.}}{\text{T.L.}}$ ratios agrees with the one obtained previously for the $\frac{\text{T.L.}}{\text{S.L.}}$ ratios of the Lake Erie sheeps-

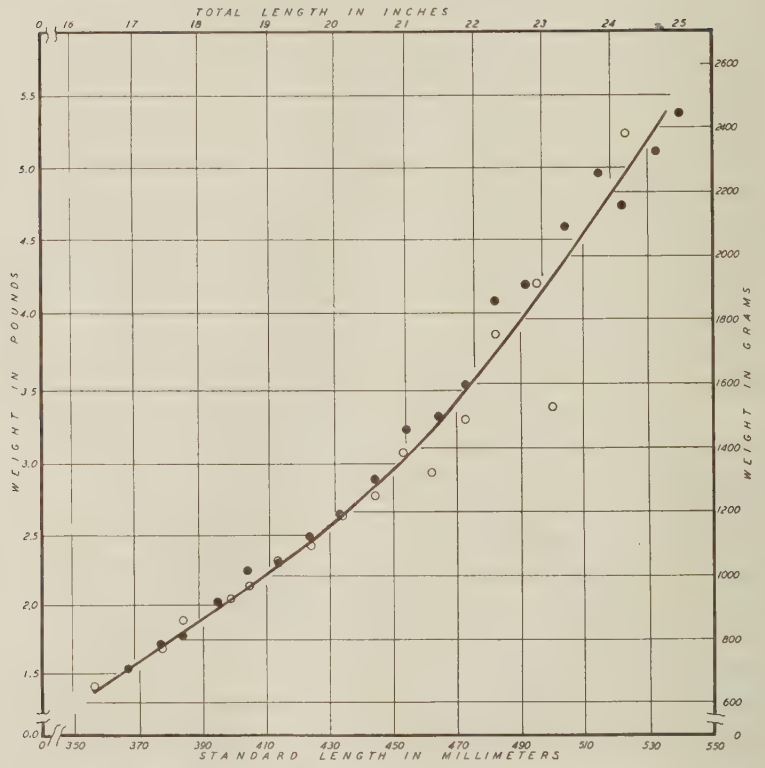

FIG. 3. Length–weight relationship of Lake Huron whitefish. Males represented by open circles; females, by black dots. Data from Table VIII

head (Van Oosten, 1938), although the change in the whitefish ratios is not so marked as that found in the sheepshead. To facilitate the conversion of either standard or total length expressed in any unit of measurement to the other length expressed in the same or a different unit a table of conversion factors based on the $\frac{\text{S.L.}}{\text{T.L.}}$ ratios was constructed (Table IX). For example, the $\frac{\text{S.L.}}{\text{T.L.}}$ of whitefish less than 250 millimeters, standard length, was found to be 0.846,

TABLE IX

FACTORS FOR THE CONVERSION OF TOTAL AND STANDARD LENGTHS OF THE LAKE HURON WHITEFISH

Length interval in mm.	No. of specimens	Conversion factors			
		T.L.* to S.L.* (no change in units of length)	S.L. to T.L. (no change in units of length)	S.L. (mm.) to T.L. (inches)	T.L. (inches) to S.L. (mm.)
Under 250	37	0.846	1.182	0.04654	21.49
250–549..	1,495	0.851	1.175	0.04626	21.62
Over 549.	50	0.860	1.163	0.04579	21.84

* T.L. = total length; S.L. = standard length.

and to convert T.L. to S.L. it is necessary to multiply by this factor. The reciprocal $\left(\frac{\text{T.L.}}{\text{S.L.}}\right)$ equals 1.182, and this value must be used to change S.L. to T.L. To convert T.L. (inches) to S.L. (mm.) it is necessary to multiply by 21.49 (0.846×25.4), and to convert S.L. (mm.) to T.L. (inches), to multiply by $0.04654 \left(\frac{1.182}{25.4}\right)$.

The coefficient of condition, K,[1] was determined for all whitefish that were weighed. The 1923 averages computed for individuals grouped in 10-millimeter length intervals were arranged in tabular form in accordance with the length interval, sex, and age group. A study of these data revealed no consistent change in K either with an increase in the length of the fish within an age group or with an increase in the age of the fish within a length group. Neither was there a consistent change with length when the K data of all age groups were combined, except for a slight tendency among the largest females to have coefficients above the average. There was, therefore, no correlation between growth rate and the coefficient of condition, and the presentation of the data in summary form will suffice. These are given in Table X. It may be seen from this table that the K values averaged consistently higher in the females than in the males and that in neither sex do they vary consistently

[1] $K = \frac{W \times 10^5}{L^3}$; W = weight in grams, L = standard length in millimeters.

TABLE X

COEFFICIENT OF CONDITION, *K*, ACCORDING TO AGE AND SEX OF THE LAKE HURON WHITEFISH TAKEN OFF ALPENA JULY 3 AND 10, 1923, AND NOVEMBER 15, 17, AND 19, 1924

Numbers in parentheses indicate number of fish employed.

Year of capture	Sex	Age group								Grand average
		III	IV	V	VI	VII	VIII	IX	X	
1923	Male	1.47	1.46	1.46	1.44	1.58	...	...	...	1.46
		(8)	(157)	(36)	(12)	(2)	...	...	...	(215)
	Female	1.51	1.49	1.53	1.51	1.54	...	...	...	1.50
		(11)	(146)	(48)	(14)	(5)	...	...	...	(224)
	Male and female	1.49	1.47	1.50	1.48	1.55	...	...	...	1.48
		(19)	(303)	(84)	(26)	(7)	...	...	...	(439)
1924	Male	1.33	1.19	1.21	1.17	1.16	...	1.16	1.26	1.18
		(2)	(2)	(6)	(32)	(8)		(2)	(1)	(53)
	Female	...	1.32	1.78	1.38	1.49	1.44	...	1.17	1.41
			(2)	(1)	(4)	(2)	(1)		(1)	(11)
	Male and female	1.33	1.30	1.38	1.21	1.23	1.44	1.16	1.22	1.26
		(7)	(7)	(10)	(37)	(10)	(1)	(2)	(2)	(76)

in any one direction with the age groups. The coefficients were lower in 1924 (grand average 1.26) than in 1923 (grand average 1.48), which suggests that the whitefish were in better condition in the summer than in the fall when on the spawning grounds. In comparison with related species in the Great Lakes, the whitefish has a high coefficient of condition indicative of a relatively heavy body form. The Lake Superior longjaw was found to have an average *K* value of 1.02 and the Lake Huron herring a value of 1.13 (Van Oosten, 1937).

VII. SEXUAL MATURITY

Tables XI and XII present the available data on the sexual maturity of the Lake Huron whitefish. Since all the specimens taken in 1924 were sexually mature the 1923 data only are employed. Table XI shows for the males of each age group and of all age groups combined the length frequencies, average length, average weight, and percentage composition of the immature and mature fish. The percentages of mature fish at each length interval are shown in the column at the extreme right. Table XII provides similar data for the females.

TABLE XI

SEXUAL MATURITY OF THE LAKE HURON WHITEFISH (MALES) TAKEN OFF ALPENA, JULY 3 AND 10, 1923. LENGTH FREQUENCIES OF IMMATURE AND MATURE MALES, AVERAGE LENGTHS, AND PERCENTAGES OF IMMATURE AND MATURE FISH IN EACH AGE GROUP; AT RIGHT, PERCENTAGE OF MATURE MALES AT EACH LENGTH (ALL AGES COMBINED)

Numbers in parentheses indicate number of fish employed.

Standard length interval in mm.	Total length in inches (converted) *	Age group and sexual maturity (males)										Percentage mature at each length interval
		III		IV		V		VI	VII	III–VII		
		I†	M†	I	M	I	M	M	M	I	M	
350–359	16.4	...	...	1	...	...	...	...	...	1	...	0
360–369	16.9	...	...	...	...	...	...	...	...	...	...	...
370–379	17.3	...	...	2	...	...	...	...	...	2	...	0
380–389	17.8	1	1	2	1	...	1	...	...	3	3	50
390–399	18.3	...	1	...	22	1	...	...	...	1	23	96
400–409	18.7	...	2	4	18	...	1	...	...	4	21	84
410–419	19.2	...	...	3	40	1	1	...	...	4	41	91
420–429	19.7	...	3	1	28	...	5	...	...	1	36	97
430–439	20.1	...	...	...	23	...	7	...	...	...	30	100
440–449	20.6	...	...	...	6	...	5	...	...	...	11	100
450–459	21.0	...	...	...	3	...	4	1	...	...	8	100
460–469	21.5	...	...	...	2	...	4	1	...	...	7	100
470–479	22.0	...	...	...	...	...	5	5	...	...	10	100
480–489	22.4	...	...	...	1	...	1	2	...	...	4	100
490–499	22.9	...	...	...	...	...	...	1	1	...	2	100
500–509	23.4	...	...	...	...	...	...	2	...	...	2	100
510–519	23.8	...	...	...	...	...	...	...	...	...	...	...
520–529	24.3	...	...	...	...	...	...	...	1	...	1	100
Total number....		1	7	13	144	2	34	12	2	16	199	
Percentage immature and mature		12	88	8	92	6	94	100	100	7	93	
Average length (mm.).....		388	410	397	417	404	444	478	509	397	426	
Average weight in pounds.....		1.88 (1)	2.24 (7)	1.90 (13)	2.37 (144)	2.19 (2)	2.78 (34)	3.47 (12)	4.63 (2)	1.93 (16)	2.52 (199)	

* The mid-value of each interval was converted by means of the conversion factor 0.04626.

† I = Immature; M = Mature.

From Table XI it may be observed that the majority (88–94 per cent) of the males of age groups III to V and all older males were sexually mature or maturing. Only 7 per cent of the males taken were immature. These measured consistently smaller than the mature adults of the same age; the average differences in length

TABLE XII

SEXUAL MATURITY OF THE LAKE HURON WHITEFISH (FEMALES) TAKEN OFF ALPENA, JULY 3 AND 10, 1923. LENGTH FREQUENCIES OF IMMATURE AND MATURE FEMALES, AVERAGE LENGTHS, AND PERCENTAGES OF IMMATURE AND MATURE FISH IN EACH AGE GROUP; AT RIGHT, PERCENTAGE OF MATURE FEMALES AT EACH LENGTH (ALL AGES COMBINED)

Numbers in parentheses indicate number of fish employed.

Standard length interval in mm.	Total length in inches (converted) *	Age group and sexual maturity (females)										Percentage mature at each length interval
		III	IV		V		VI		VII	III–VII		
		I †	I	M †	I	M	I	M	M	I	M	
360–369	16.9	1	2	...	...	...	...	...	...	3	...	0
370–379	17.3	1	1	...	...	...	...	...	...	2	...	0
380–389	17.8	1	6	...	...	...	...	...	...	7	...	0
390–399	18.3	2	9	1	3	...	...	...	...	14	1	7
400–409	18.7	3	23	4	1	...	...	...	...	27	4	13
410–419	19.2	2	28	9	2	...	...	1	...	32	10	24
420–429	19.7	...	16	12	2	6	1	...	...	19	18	49
430–439	20.1	1	9	6	2	5	...	...	...	12	11	48
440–449	20.6	...	2	7	1	7	...	...	...	3	14	82
450–459	21.0	...	1	3	...	4	...	1	...	1	8	89
460–469	21.5	...	...	2	...	7	...	6	...	...	15	100
470–479	22.0	...	...	1	...	6	...	1	...	...	8	100
480–489	22.4	...	...	3	...	1	...	...	...	...	4	100
490–499	22.9	...	...	1	...	1	...	...	...	...	2	100
500–509	23.4	...	...	1	...	...	...	...	2	...	3	100
510–519	23.8	...	...	...	...	...	...	1	...	...	1	100
520–529	24.3	...	...	...	...	...	...	2	2	...	4	100
530–539	24.8	...	...	...	...	...	...	1	...	...	1	100
540–549	25.2	...	...	...	...	...	...	...	1	...	1	100
Total number....		11	97	50	11	37	1	13	5	120	105	
Percentage immature and mature		100	66	34	23	77	7	93	100	53	47	
Average length (mm.).....		398	411	434	416	451	423	478	520	410	450	
Average weight in pounds.....		2.09 (11)	2.26 (96)	2.79 (50)	2.33 (11)	3.15 (37)	2.44 (1)	3.72 (13)	4.77 (5)	2.25 (119)	3.13 (105)	

* The mid-value of each interval was converted by means of the conversion factor 0.04626.

† I = Immature; M = Mature.

and weight amounted to about 25 millimeters (1 inch) and 7.7 ounces. Since the gill nets selected only the larger individuals of age group III it is safe to assume that the percentage of immature fish in this group is larger than that indicated in the table (12 per cent). Since age group IV is representative and 92 per cent of these fish were

found to be mature, it may be concluded that nearly all male whitefish at Alpena are sexually mature or reach sexual maturity in the fifth year of life at an average standard length of 417 millimeters (19.3 inches total length) and a weight of 2.4 pounds. The percentages at the right of the table substantiate this conclusion. At 385 millimeters (17.8 inches total length, 1.9 pounds) 50 per cent of the fish were still immature and at 415 millimeters (19.2 inches total length) 9 per cent were immature.

The females develop sexually later in life than do the males (Table XII). All the III-group fish were immature, and 66 per cent of the IV-group, 23 per cent of the V-group, and 7 per cent of the VI-group females were sexually immature. All the VII-group fish were mature. Some 53 per cent of the females taken in 1923 were undeveloped sexually. Like the males, these undeveloped females measured consistently smaller than the adults of the same age, with the average differences in length and weight amounting to 25 millimeters (1 inch) and 9.1 ounces. The data indicate that nearly all female whitefish were sexually mature or reached sexual maturity in the seventh year of life at an average standard length of 478 millimeters (22.1 inches total length) and a weight of about 3.8 pounds. This conclusion is supported by the percentages shown at the extreme right of the table. At 435 millimeters (20.1 inches total length) only 48 per cent of the females were found to be mature or maturing, and not until a length of 465 millimeters (21.5 inches total length) was reached were all individuals mature.

On the basis of this analysis of maturity it is seen that, in order to protect fully the immature whitefish of both sexes, it is necessary to establish a minimum size limit at which they may be taken of 22 inches total length, or about $3\frac{1}{2}$ pounds in the round.

VIII. SEX RATIO

The sex ratios, expressed both as percentages and as the number of females per 100 males, are shown in Table XIII for each age group of the Lake Huron whitefish collected in midsummer in 1923 and in the fall of 1924. The grand averages for all age groups combined are given in the column at the extreme right. Because the 1924 materials were collected from a spawning run the 1923 samples furnish the more representative data on the ratio in the general population. The grand averages indicate that this ratio is approxi-

TABLE XIII

Sex Ratios according to Age of the Lake Huron Whitefish as Determined from Samples Collected in Midsummer and from the Fall Spawning Run

Numbers in parentheses indicate number of fish employed.

Date of collection	Sex	Age group III	IV	V	VI	VII	VIII	IX	X	XI	XII	All groups
July 3 and 10, 1923	Males, percentage	42 (8)	52 (157)	43 (36)	46 (12)	29 (2)	...	...	...	...	...	49 (215)
	Females, percentage	58 (11)	48 (147)	57 (48)	54 (14)	71 (5)	...	...	...	...	...	51 (225)
	Females per 100 males	138	94	133	117	250	...	...	...	...	...	105
Nov. 15, 17, and 19, 1924	Males, percentage	100 (4)	90 (18)	90 (28)	95 (298)	88 (72)	76 (13)	81 (25)	83 (10)	100 (3)	100 (2)	91 (473)
	Females, percentage	0	10 (2)	10 (3)	5 (17)	12 (10)	24 (4)	19 (6)	17 (2)	0	0	9 (44)
	Females per 100 males	0	11	11	6	14	31	24	20	0	0	9

mately 50 : 50 (49 per cent males, 51 per cent females). In the 1924 whitefish, however, the males were strongly dominant (91 per cent), indicating that these fish were taken at the beginning of the spawning run (it has been asserted repeatedly that in the whitefish the males precede the females on the breeding grounds). This marked dominance persisted in all age groups and, therefore, cannot be attributed to the fact that the females mature later in life than the males, although this factor could explain a decided male dominance in age groups III and IV and a moderate dominance in age groups V and VI. The 1924 data indicate, further, that a tendency exists for the males to become relatively less numerous than the females in the older groups. Computations show that age groups III–VII comprised 93 per cent males and 7 per cent females, or 8 females per 100 males. Age groups VIII–XII consisted of 82 per cent males and 18 per cent females, or 23 females per 100 males. This change in sex ratio is also suggested by the 1923 data, in which age groups III-IV comprised 51 per cent males and 49 per cent females, or 96 females per 100 males, and age groups V–VII included 43 per cent males and 57 per cent females, or 134 females per 100 males. This

changing sex ratio is in all probability correlated in part at least with the earlier attainment of sexual maturity by the males and the consequent tendency for them to enter the commercial catch at an earlier age than do the females.

IX. SUMMARY

1. This study was based on whitefish, *Coregonus clupeaformis* (Mitchill), obtained from Lake Huron. All the data except those on standard length–total length ratios were based on all or on part of the 982 specimens taken with gill nets and a pound net lifted off Alpena, Michigan, on July 3 and 10, 1923, and on November 15, 17, and 19, 1924. The 1,582 whitefish used for the study of length conversion ratios were taken with deep trap nets and pound nets at several ports during the period 1928–35.

2. The 1923 summer collection was composed of fish of age groups III–VII. Age group IV (1919 year class) predominated, comprising 69.7 per cent of the catch. The bulk (88.5 per cent) of the samples consisted of individuals of age groups IV and V. Ninety-three per cent of the specimens ranged from 380 millimeters (17.6 inches total length) to 480 millimeters (22.2 inches total length), standard length. The average standard length of all individuals was 426 millimeters (19.7 inches total length).

3. The 1924 fall collection was composed of larger and older fish than was the 1923 sample. The former comprised age groups III–XII. Age group VI (1918 year class) predominated, comprising 59.8 per cent of the catch. The bulk (75.3 per cent) of the samples consisted of fish of age groups VI and VII. Ninety per cent of the specimens ranged from 440 millimeters (20.4 inches total length) to 560 millimeters (25.6 inches total length), standard length. The average standard length of all individuals was 497 millimeters (23.0 inches total length).

4. The data indicate that each year class is exposed to intensive fishing by commercial gill nets for at least four consecutive years — during two successive summers and two consecutive autumns.

5. In terms of length the two sexes grew at the same rate, but the females tended to be somewhat heavier than the males at corresponding lengths and ages.

6. The whitefish grows most rapidly in length during the first year, when it reaches a standard length ranging from 94 to 117 milli-

meters (about 4.5 to 5.5 inches total length). An unexpected increase in the general growth rate during the fourth year was found to be truly characteristic of the Alpena specimens. It was suggested that this phenomenon might be indicative of a general movement of whitefish in their fourth year from shallow to deep water.

7. The annual increment of growth in weight increased progressively during at least the first seven and one-fourth years of life. The data indicate that whitefish of this age with an average total length and weight of about 24 inches and 4.7 pounds are still in the midst of a fast-growing period of life. From an economic point of view, therefore, the whitefish should be protected until they reach a total length of at least 25 inches.

8. The "law of growth compensation" was found to apply to the Lake Huron whitefish.

9. A single curve was found suitable to express the length–weight relationship of both males and females at various lengths. The curve showed that the weight of the whitefish increased proportionately more rapidly than did the length. By the use of several conversion factors derived from standard length–total length ratios it is possible to convert either standard or total length expressed in any unit of measurement to the other length expressed in the same or a different unit. The curve facilitates the conversion of standard length in millimeters to total length in inches and vice versa, and of weight in grams to weight in pounds and vice versa.

10. The standard length–total length ratios increased with an increase in the length of the fish.

11. The coefficient of condition, K, showed no consistent change with the length of the fish within an age group or with the age of the fish within a length group, and hence no correlation existed between K and growth rate. The K values averaged consistently higher in the females than in the males and in summer (1923) than in the fall (1924), which suggests that the whitefish were in better condition in summer than in the fall previous to spawning.

12. Nearly all the male whitefish were sexually mature or reached sexual maturity in the fifth year at a total length of 19.3 inches and a weight of 2.4 pounds. The females developed sexually later in life. Nearly all were mature or reached sexual maturity in the seventh year at a total length of 22.1 inches and a weight of about 3.8 pounds. In both sexes the immature fish averaged less in length and weight

than did the mature specimens of the same age. In order to protect fully the immature whitefish at Alpena, Michigan, it is necessary to establish a minimum size limit of 22 inches total length, which is equivalent to about $3\frac{1}{2}$ pounds.

13. The sex ratio in the general population was found to be 50 : 50, although a tendency existed for the males to become relatively less numerous than the females in the older age groups. The fall collection of 1924 was strongly dominated by males, which indicates the correctness of the repeated statements that the male whitefish precede the females on the breeding grounds.

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